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WETLAND WONDERS

Instructional Materials for the Study of Midwestern Wetlands

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Special Publication 14
September 1992

Illinois Natural History Survey, Lorin I. Nevling, Chief
A Division of the Illinois Department of Energy and Natural Resources

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Citation:
Jeffords, M.R., A.S. Hodgins, and S.P. Havera. 1992. Wetland wonders. Illinois Natural History Survey Special Publication 14. 68 pp.

Editor: John Ballenot
Cover photo: Michael Jeffords
Cover design: Nancy Loch

Printed by authority of the state of Illinois
(89028-1,500-9-92)
ISSN 0888-9546

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7/13/92

Acknowledgments

The authors thank Liane Suloway, Illinois Natural History Survey, and Jim McGaughey, Eastern Illinois University, for reviewing the manuscript. Members of the Survey scientific staff made important contributions. Susan Post offered creative suggestions for several activities, wrote the slide captions, and compiled the glossary. Marilyn Morris, Liane Suloway, Joyce Hofmann, Dennis Keene, John Taft, Chris Mayer, and Kevin Cummings provided technical information. Special thanks go to Patti Malmborg for executing the poster. In addition, we thank John Ballenot for editing and formatting the final manuscript. We also acknowledge the Illinois State Museum, the Illinois Department of Energy and Natural Resources, and the Departments of Horticulture and Agronomy at the University of Illinois at Urbana-Champaign for allowing us to reproduce artwork from their publications *Aquatic Plants of Illinois, Citizen Stream Monitoring: A Manual for Illinois,* and *Illinois Pesticide Applicator Training Manual 39–6: Aquatics.*

Funding for this cooperative project was provided by the North Central Region of the U.S. Fish and Wildlife Service through its Service Challenge Grant Program.

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How to Use This Publication

Although the materials in this publication are intended for use in middle school classrooms, they can be readily adapted for younger or older students and for less structured settings, such as summer programs, 4-H clubs, Scouts, and FFA. Classroom teachers may elect to integrate these materials into an existing unit of the science curriculum or to create a new wetlands unit. Several of the activities can be incorporated into the language arts or social studies curriculum or used during the art period. This across-the-curriculum approach is a useful reinforcement strategy that shortens and intensifies the wetlands unit.

Part One of this publication provides teachers with necessary background information, including information on the genesis, characteristics, and major functions of wetlands. This section also discusses the current status of wetlands and the need for preservation and restoration. Teachers will probably want to share this information with their students in a less formal manner and in conjunction with specific activities. They will also want to supplement this material with information from textbooks and library resources.

Part Two, Twelve Activities for Young People, is the heart of the publication. The format includes a statement of the instructional objective; lists of the skills emphasized in the activity, the scientific vocabulary required, and the materials needed to complete the activity; a detailed description of the procedure for carrying out the activity; and a suggested evaluation. Some activities rely on student handouts, and copies suitable for reproducing are included. Suggestions for using these activities are given in the opening paragraphs of Part Two.

Appendix A describes the 20 color slides that accompany this publication. The slides and commentary are arranged independently of the teacher text and student activities to permit greater flexibility in their use. The slides are meant to be used in sequence with the commentary but also to be integrated with the information in Part One. Some are particularly useful with a given activity in Part Two. Cues for their integration are given in the text. Activity Twelve, Wetland Views and Reviews, relies on the slides as a vehicle to demonstrate what has been learned in the study of wetlands.

This wetlands instructional package also includes a sample copy of a poster depicting 31 wetland plants and animals. Classroom sets of 30 posters on heavier paper stock can be obtained for $3.50 by writing to Distribution Center, Illinois Natural History Survey, 607 East Peabody Drive, Champaign, Illinois 61820 (phone: 217-333-6880). Activity Ten, Picture Perfect, suggests how the poster may be used and includes a key that identifies the pictured plants and animals.

Part One: The Wetlands Story

Midwesterners generally perceive wetlands as unattractive, unproductive, wasteland areas that might better be drained and "put to some use" **(Slide 1).** Although we lament the fate of tropical rainforests, we often fail to see the importance of preserving and restoring our own wetlands and continue to ruin them at an astonishing rate. During a single hour, 60 acres (an area equivalent to 58 football fields) of wetland habitat are destroyed in the United States! Only through formal and informal education, especially of those who will vote and pay taxes in the next decade, can the struggle to understand, appreciate, save, and restore our wetland habitats be advanced and eventually won. This educational package, developed by scientists at the Illinois Natural History Survey with funding provided by the U.S. Fish and Wildlife Service, will help young people to understand the crucial link between wetlands preservation and the health of our environment, the overall landscape, and our society.

What's a Wetland?

Wetlands, which cover about 6% of the earth's land surface, can be defined rather simply as areas that are part land and part water and in which water is the controlling environmental factor. Several more complex definitions have recently been developed by the federal government, but these are lengthy and controversial. In general, wetlands exhibit the following characteristics:

1. The water table (the upper limit of that portion of the ground that is entirely saturated with water) remains at or near the surface, and water covers the land at least part of the year.
2. The soils are hydric (wet for most of the year and low in oxygen).
3. The plants that grow there are adapted to life in water or saturated soil (hydrophytes). Plant material accumulates rapidly in wetlands and decays very slowly.

In short, wetlands occupy areas between terrestrial (land) and aquatic (water) habitats and have developed ecosystems that are uniquely their own.

Water Work

Wetlands can be classified into a variety of forms, each with its own special profile. Swamps, marshes, bogs, seeps, and fens are perhaps the most familiar. Illinois alone has many different wetland habitats that vary in climate, water supply, soil type, and plant and animal residents. Throughout the Midwest, wetlands range from those where the soil is saturated for at least part of the year to those with permanently standing water, from wetlands associated with the seasonal changes that occur along a river to those that were formed directly or indirectly by the action of ancient glaciers, from wetlands characterized by organic soils (soils made primarily from decayed plants) to those where inorganic (mineral) soils predominate, and from grassy wetlands to those that are forested. No two wetlands are alike, and each is an important ecosystem with influence far beyond its perimeters.

In much of the Midwest, wetlands were formed either by the action of glaciers or by rivers. During the last Ice Age, before the Wisconsinan Glacier retreated some 7,000–12,000 years ago, great chunks of ice broke off from the main body of the glacier and were left behind to melt and form lakes **(Slide 2)**. In other areas, glaciers merely scooped out shallow depressions that allowed water to accumulate as the ice retreated.

Wetlands formed by rivers are of several types, including oxbow marshes, floodplain bottomlands, and backwater lakes. When a meandering river changes course and leaves a portion of its channel isolated except when the river floods, an oxbow pond is formed. In time, this pond fills in and becomes an oxbow marsh. Floodplain bottomlands are created by periodic flooding and include bottomland forest, swamp, and marsh habitats. Backwater (bottomland) lakes form when soil and sand settle out of river currents and form long islands in the river. If such an island becomes high enough to completely separate the side channel from the main river, a bottomland lake is formed. In addition, human activities create as well as destroy wetlands, and some wetlands are produced by impoundments, excavations, and the construction of dikes.

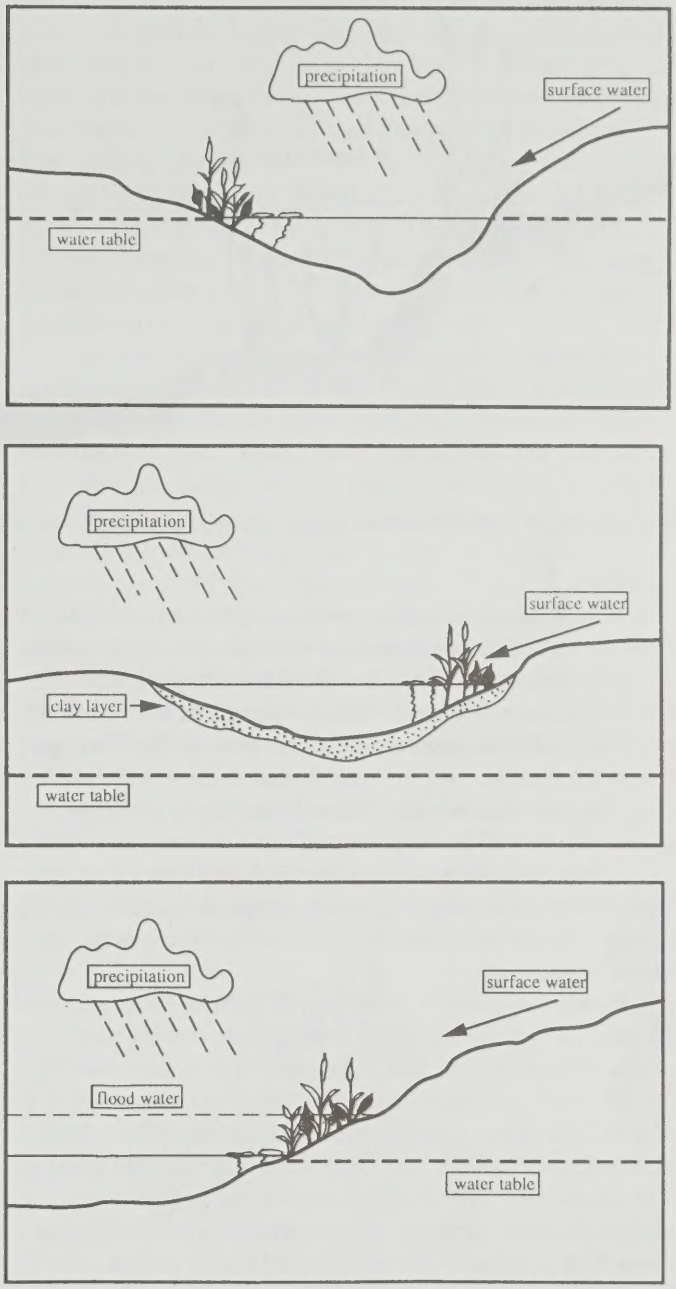
The types of plants and animals found in oxbow marshes and backwater lakes are determined largely by the periodic flooding of these areas by the main river. Because this annual flood is a predictable and recurring phenomenon, many organisms have evolved adaptations that enable them to exploit the seasonally expanded habitat and the food brought in by the flood. Times of low water, however, are just as important as flooding. A low water level concentrates fish into shallow pools where herons and egrets obtain food for nestlings **(Slide 3)**; it exposes mudflats where moist-soil plants grow and produce seeds sought by waterfowl; and it allows soils to drain and be exposed to oxygen, thereby speeding the processes of decay and the recycling of nutrients.

To a lesser extent, beavers play a role in the formation of midwestern wetlands. When a beaver dams a stream, water accumulates behind the dam, and a pond or small lake forms. When the beaver abandons the site, usually because local food sources have been depleted, the dam eventually

begins to leak, and a wetland of sorts forms upstream. Wetland plants and animals persist in the area as long as the soil remains saturated.

Midwestern wetlands can have either mineral (inorganic) or organic soils. Mineral soils are composed largely of sand, silt, or clay. Organic soils, generally called peat or muck, are formed from plant material that has partially decayed in wet ground that is low in oxygen (anaerobic). These soils are low in oxygen because standing water has partially insulated the plant material from the atmosphere. Organic soils take up (absorb) chemicals from the environment better than inorganic soils, an important attribute that will be discussed later in more detail.

Hydrology, or the way water is distributed on or below the earth's surface, is important in classifying wetlands in the Midwest. In general, wetlands have two sources of water: surface water from precipitation (rain, snow, ice) and groundwater (the water found below the surface of the soil). A depression that is deep enough to extend below the water table forms a wetland fed by both groundwater and surface water. A depression that does not extend below the water table receives only surface water, such as precipitation and runoff from the surrounding land. Wetlands found on slopes, usually surrounding a lake, pond, or stream, may receive water from several sources, including runoff and floodwater. The length of time the area remains saturated depends on the degree of slope, soil characteristics, and the frequency of flooding or runoff from precipitation. Knowing how a wetland receives its water (its hydrology) is crucial for protecting and managing that area.

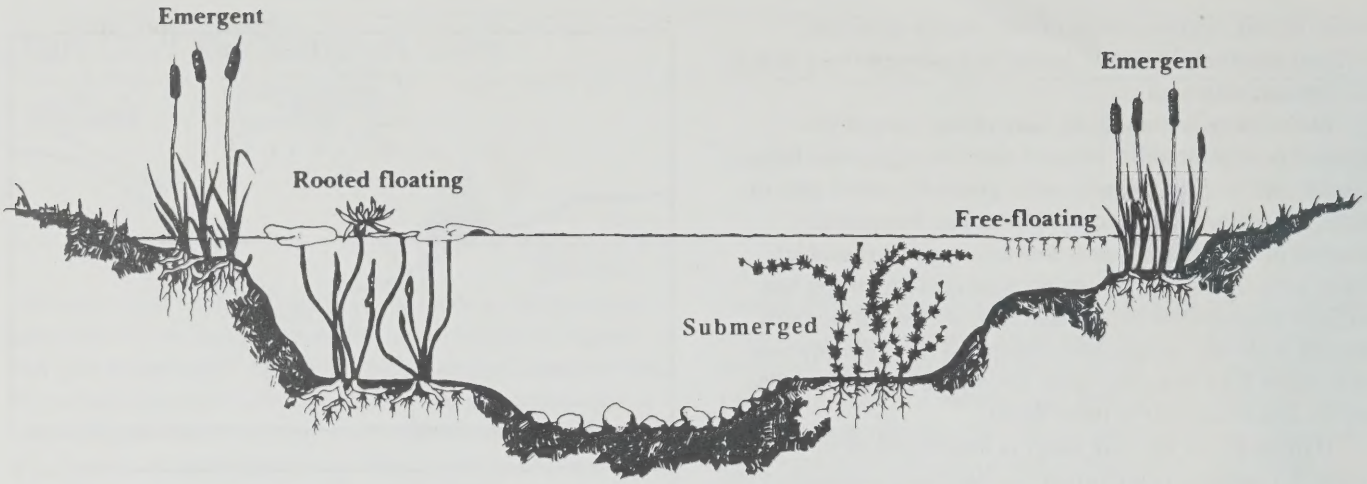


Three examples of wetland hydrology: water sources are runoff from precipitation and groundwater (top); water source is runoff from precipitation (middle); water sources are runoff from precipitation, periodic floodwater, and some groundwater (bottom).

Flora and Fauna

Plants are important in helping us decide what is or is not a wetland. Unlike a wetland's hydrology, its plants are highly visible and easily identified. Water depth is perhaps the most influential physical factor in determining the kinds of plants that inhabit a site. Because more plant species are adapted to moist-soil conditions than to open water (strictly aquatic conditions), the shallower the water, the greater the diversity of species.

Many interesting plant types occur in wetlands. Recent surveys document that more than 100 of the 172 families of vascular plants that occur naturally in Illinois contain species that thrive in aquatic or moist-soil habitats. Vascular plants, you may recall from your biology courses, are those with both xylem (supporting and water-conducting tissue) and phloem (food-conducting tissue). Floating-leaf plants such as water lilies are rooted deep below the surface of the water and send up broad, flat leaves that rest on the surface, where photosynthesis occurs. Nutrients move between the leaves and the underwater roots via the plants' long, slender, flexible stems **(Slide 4)**. Free-floating plants such as duckweeds are not rooted but remain on the surface of the water, usually with their roots dangling **(Slide 5).** By contrast, emergent plants, including cattails, arrowheads, and bulrushes, are amphibious; that is, they grow with their roots in wet soil for all or part of the year and send up leaves that stand erect above the surface of the water. Submerged plants like pondweeds are also rooted in the soil, but their stems and leaves remain entirely underwater. Other plant types that occupy the drier portions of wetlands include moist-soil plants (sedges), moist-soil shrubs (buttonbush and red osier dogwood), and moist-forest species (tamarack, bald cypress, and silver maple). Some wetlands contain all of these vegetation types, but others have only one or two. Along with water chemistry and hydrology, differences in vegeta-



Various growth forms of wetland plants. The type of plants found in an area is important for determining whether the area is a wetland.

tion help us not only to determine the presence of a wetland but also to distinguish among the various types of wetlands.

Not all wetland plants are beneficial. Purple loosestrife is a prime example of an introduced plant that is threatening our native wetland communities. The seeds of this European native were stowaways in ships' ballast and on livestock or were intentionally brought to the United States by immigrants. By the 1830s this perennial had become established in the Northeast. With none of its insect or disease enemies from Europe to regulate its growth, purple loosestrife rapidly marched across the wetlands of the continent, replacing the native vegetation.

Purple loosestrife's reproductive abilities are prodigious. Its shallow root system forms a dense mat, making adult plants difficult to pull; and if the entire root is not removed, the plant will resprout. When the plants, which average 4–6 feet tall, are mowed, stem pieces send out new roots. Each plant's flower spike can produce more than 120,000 seeds in a single season. The seeds can remain viable when submerged in water for many years, waiting only for a summer drought to germinate. In one growing season purple loosestrife can cover a marsh.

As purple loosestrife multiplies, it aggressively crowds out other vegetation required by wildlife. In addition, purple loosestrife has very little wildlife value of its own. Song birds do not eat its small hard seed; muskrats prefer cattail for their homes and for food; ducks shun wetlands that have become dominated by loosestrife; and the plant is too compact to offer much cover for wildlife. When loosestrife invades, wetlands once rich in native plants and animals can suddenly become a single-species stand of little value to humans or wildlife.

Identifying a wetland by looking at its animals, which are mobile, is more difficult than relying on its plants, which usually stay put. The degree to which animals depend on wetland habitats is sometimes determined by their mobility and can vary greatly depending on the season. Although many mammals visit wetlands, only a few species—most notably the muskrat, beaver, and river otter—are adapted to water and to living among water-loving plants. Several other species—from the rare rice rat and swamp rabbit to the common white-tailed deer, raccoon, and mink—use wetlands to various degrees. The swamp rabbit, for example, is rarely found far from water and inhabits floodplain forests, cypress swamps, and areas where low ridges alternate with wooded sloughs or grassy marshes. Rice rats live in areas characterized by standing water with a dense cover of emergent vegetation, including sedges, rushes, and cattails.

Birds are unique among wetland inhabitants because many are migratory and rely on widely separated wetlands on a seasonal basis; these migrants may return year after year to the same wetlands to feed and raise their young **(Slide 6)**. Other migrant species do not nest in wetlands but depend on them for forage and rest during long migrations. Waterfowl, shorebirds, and numerous songbirds all rely on wetland habitats. The more water-loving the species, the deeper the water it needs. Diving ducks, for example, require deeper water than dabbling ducks to obtain their food. Because the habitat requirements of some species are highly specific, and others require several different habitats, the conservation of a great diversity of wetland habitats or wetland complexes is essential to the preservation of the full range of bird species.

Most amphibians require water to reproduce, and many reptiles and amphibians also find wetlands ideal foraging or feeding grounds. In spring and early summer, wetlands are alive with calling toads and frogs, their mating success soon evidenced by strings of eyelike eggs floating in the still waters **(Slide 7)**. Frogs and toads will eat just about anything that moves and is an appropriate size. In turn, they are food for many species of snakes, birds, and mammals. Many kinds of snakes live in or near water. They are excellent swimmers and hunt fish, frogs, and other organisms associated with wetlands. Although the role of all of these creatures in the overall "balance of nature" is poorly understood, their existence is undoubtedly essential to many other

organisms. At the very least, these creatures are a delight to those fortunate enough to spot them in their wetland habitats.

Wetlands also serve as breeding grounds for many species of fish. The variety of fish species found in a marsh, however, is relatively small and includes only those that can tolerate muddy conditions and relatively warm water for at least part of the year. The pumpkinseed sunfish is a species typically found in midwestern ponds and marshes. The yellow perch, another midwestern wetlands species, travels in schools and feeds on minute plants and animals (plankton), insects, and other fish.

Although most of us are unacquainted with the invertebrates, the least conspicuous but most abundant animals in any wetland habitat, they play an essential role in making plant energy available to other animals. Among the invertebrates present in midwestern wetlands are protozoa, sponges, flatworms, worms, crustacea, mollusks (clams and snails), and insects **(Slide 8)**. Although most of the insects are terrestrial, a significant number (about 10%) are adapted for living in water. Among the fairly common but uncelebrated insects of wetlands are crawling water beetles, giant water bugs, water scorpions, dragonflies, and mayflies **(Slide 9)**. In some types of wetlands, such as deep- and shallow-water marshes, mollusks are dominant and form an important food source for fish and diving ducks. The presence of unionid mollusks (big clams) is also a fairly reliable indicator of relatively clean, pollution-free water.

The plant and animal communities found in wetlands are extremely complex and are tied to one another through food webs and nutrient cycles—but more about that later.

Wetland Types

Only a few of the dozens of midwestern wetland types can be characterized here. Even a cursory understanding of their remarkable diversity, however, makes clear why we cannot settle for preserving or restoring only "major" wetlands or what seems to the uninformed to be a generic, all-purpose wetland.

Floodplain forests usually occur along streams and rivers **(Slide 10).** Because these forests are flooded frequently, they have a lower diversity of tree species than forests located on higher ground. The understory is open but often choked with nettles and vines. Rotting logs and woody debris deposited by floodwaters are abundant. Typical trees of midwestern floodplain forests are silver maple, cottonwood, red maple, and sycamore. The soils that support these forests are usually mineral.

Marshes are dominated by emergent plants that grow with their stems partly in and partly out of the water; these include sedges, bulrushes, pickerelweed, and cattails. Water depth in marshes ranges from zero (saturated soil) to perhaps 6 feet. In midwestern marshes both floating-leaf plants and submerged aquatic plants—exemplified by water lilies and pondweeds, respectively—are frequently associated with cattails, an emergent species. The soils that underlie midwestern marshes are sometimes mineral but usually organic.

Marshes are highly productive habitats where hundreds of species of birds, insects, and other wildlife spend most of their lives. Productivity in any ecosystem is usually measured in terms of the living things that it produces (biomass). Two factors account for the high productivity of marshes. One is the ability of marsh plants to capture large amounts of energy from the sun and transform and store much of it as chemical energy in the form of plant tissue. The other is the efficient recycling of nutrients already produced, recycling accomplished as dead plants and animals decompose and become nutrients used by living organisms.

Swamps are dominated by woody plants and can be divided into forested and shrub swamps **(Slide 11).** Forested swamps, once common in the southern Midwest, are often dominated by bald cypress and water tupelo. The cypresses may reach prodigious size; in Illinois, the largest is more than 34 feet in circumference. Cypresses are also among the oldest living organisms on earth. In southern Illinois, thousand-year-old specimens can still be found. The soil in forested swamps may be either organic or mineral but usually has a topmost organic layer underlain with a mineral soil. Shrub swamps are similar to forested swamps except that less of the vegetation is in the form of trees. Typical plants include speckled alder, buttonbush, and dogwood growing in mostly mineral soils.

Bogs are found in the northern Midwest, usually in glacial depressions with restricted drainage **(Slide 12).** Bogs may be forested or grassy or have tall or short shrubs. Because of poor drainage, bogs are highly acidic (low pH),

The red flowers of the pitcher plant provide a bright spot of color in a northern bog.

and the plants that inhabit them must be adapted to this condition. Bog plants include sphagnum moss, various orchids, poison sumac, tamarack, and interesting carnivorous types such as the pitcher plant and sundew. Bog soils are always organic because of the incomplete decay of plant material in the acidic, low-oxygen water. The buildup of plant material forms a substance called peat, which forms a floating mat over the water. Highly acidic conditions do not allow decomposers such as bacteria to flourish, and this acidity, combined with the low nutrient content of the soil, inhibits the invasion of potentially competing plant species.

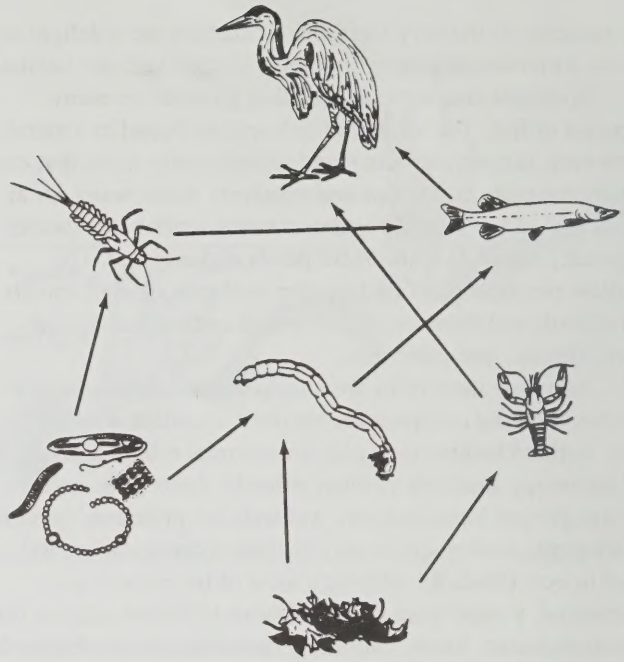
Seeps and *springs* occur throughout the Midwest and may be acidic (low pH) or basic (high pH), depending on the materials through which the groundwater flowed before reaching the surface (**Slide 13).** Seeps are common along the edges of moraines, ravines, and terraces where the groundwater meets a layer of material impervious to the downward movement of water. As a result, the water flows outward over a wide area until it reaches the surface, often at the base of a bluff or ravine. Springs have a more concentrated flow of water from a more clearly defined point in the soil. The alkalinity or acidity of the water determines the type of plants found in these habitats; the vegetation includes ferns and orchids and unusual plants such as skunk cabbage.

Fens are a type of wet meadow fed by alkaline water (high pH or basic), usually from a spring or seep. Like bogs, fens occur on organic soils and can be shrubby, grassy, or even forested. All known fens in the United States are associated with the glaciated region of the East and Midwest. Fen vegetation forms a unique community of calcium-loving plants such as shrubby cinquefoil, Ohio goldenrod, and grass-of-Parnassus. Fens are extremely sensitive to disturbance because any change in groundwater, either by pollution or changes in water level, drastically alters the habitat.

Wet prairies have a soil that is almost always organic and almost always saturated. Some standing surface water is usually present during winter and spring. As a result, the plant diversity of wet prairies is less than that of drier prairie sites. Among the typical wet prairie plants are sedges, cord grass, and blue flag iris. Most midwestern wet prairies have been drained and are now farmed.

Swales or sloughs occur around the sandy shores of the Great Lakes in depressions between old dunes. The plant community is similar to that of a grassy fen and contains plants that tolerate calcareous (basic) conditions—for example, shrubby cinquefoil, bladderwort, and arrowgrass **(Slide 14).** Swales or sloughs also occur in forested areas, often on the floodplains of fairly large streams.

Ponds and *lake margins* are classified as wetlands because they support typical moist-soil and water-loving plants. In addition, they are often surrounded by marshes or wet forests. Soils may be organic or mineral. Typical plants include arrowhead, pickerelweed, and water lily. If left undisturbed, lakes eventually fill in and are transformed into wetlands as sediment is deposited by feeder streams and carried in runoff from adjacent land.



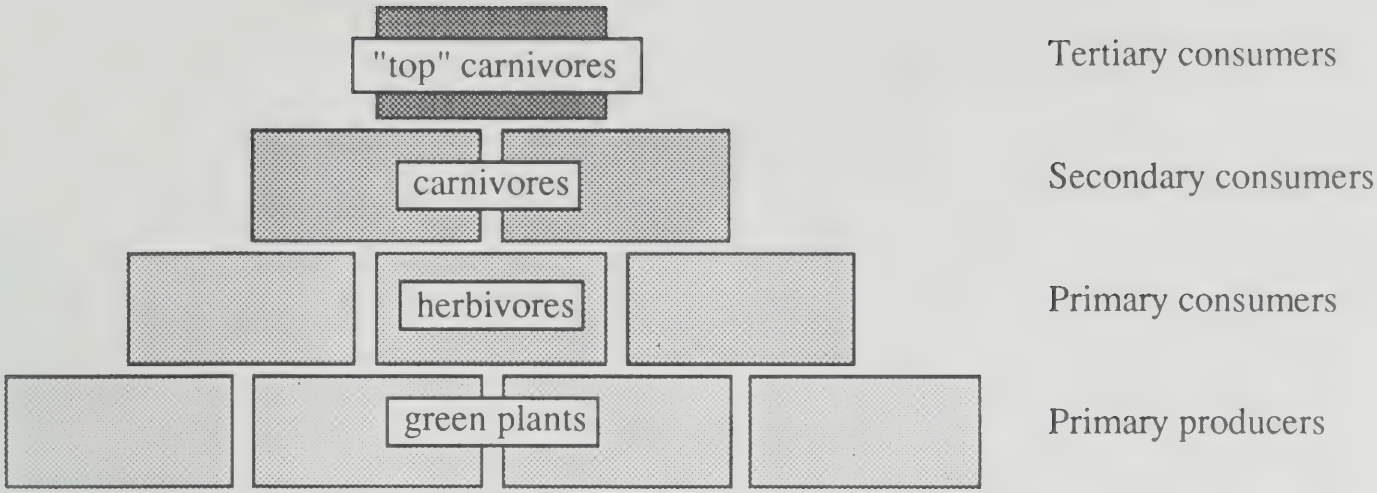
A simplified food web. Arrows indicate the direction of energy flow, from the food source (the organism being eaten) to the feeding organism.

Chains, Webs, and Pyramids

A basic process in wetland ecology, as in all ecology, is energy flow—the movement of chemical energy within a food chain. A simple wetland food chain might go something like this. As its first link we might find microscopic green algae that are producing chemical energy in the form of plant tissue from carbon dioxide, sunlight, water, and other nutrients; the process is called photosynthesis. Algae are often called the green grass of the water world, and millions of them can give water a pale green color. They are so small that a thousand medium-sized algae side by side might scarcely measure an inch. A mayfly nymph might feed on these tiny green algae and in turn be eaten by a pickerel. The pickerel might ultimately become a meal for a great blue heron. Several of these simple food chains interacting together with organisms that feed on dead material (detritivores or decomposers) and those that eat both plants and animals (omnivores) form a more complex structure that we call a food web.

When scientists study the structure and functioning of food webs, they use a specialized vocabulary to describe the relationships among various organisms. A term often used in the study of food webs and energy flow is *trophic*, a word that comes from a Greek root meaning to nourish. Trophic structure, then, is the nutritional interrelationships among organisms in a particular food chain or web, and in this context the word *nutritional* is virtually synonymous with the word *energy*.

Another way of understanding trophic structure, besides the food chain and food web, is to envision a pyramid composed of several layers. Each layer depends on those supporting it and represents a trophic level. Plants compose



Generalized trophic pyramid. Because plants can convert energy from sunlight directly into growth, they form the bottom level of the pyramid. Each of the other trophic layers depends on those that support it.

the base or bottom trophic level of the pyramid. Because they absorb the energy of sunlight and convert it into growth, plants are called primary producers. Organisms in the layer just above the primary producers are called primary consumers. Because primary consumers feed on plants, they are called herbivores. Primary consumers, however, do not merely consume food from the layer below them but are also food (or producers) for organisms in the layer above them—the carnivores. Carnivores feed on other animals and are called secondary consumers because they feed on the primary consumers, the herbivores. A particular food pyramid may have several layers of carnivores, which may feed upon other carnivorès in a fairly long succession **(Slide 15)**. All trophic pyramids, however, ultimately come to a point with a few "top" carnivores.

Unlike the nutrients carbon and nitrogen, energy does not recycle, and the chemical energy at each trophic level is not recoverable. Energy flow is a one-way street. In addition, as energy moves from one trophic level to the next, or from one organism to the next, a certain percentage of this energy is lost to keep the cellular machinery of each organism running. Only a portion of the energy goes into making tissues that are available to the next trophic level; hence, the sloping sides of the food pyramid show a reduction in the energy available from the base to the top of the pyramid. As a consequence, any ecosystem can support only a limited number of organisms, as many as can be supported by the energy available. This number is called the carrying capacity of the ecosystem.

Wetland Benefits

Wetlands, like any habitat, have an inherent beauty and interest that provide a convincing rationale for their preservation; they also serve us in ways that are essential in more immediate and selfish terms. Wetlands play a unique and irreplaceable role in maintaining the quality of our water, in controlling floods, and in providing habitat for an incredible diversity of species.

Wetlands have a profound ability to improve water quality. They reduce turbidity (cloudiness) by slowing the flow of water and allowing particles to settle out **(Slide 16).** Aquatic plants also play a role in reducing turbidity because they catch and remove solids from the water. Wetlands also work in several ways to filter out various types of pollutants—from the nitrogen and phosphorous in agricultural fertilizers washed away in runoff to the variety of chemicals in municipal and industrial wastewater. Algae and other wetland plants take up these chemicals from the water itself or from soil particles and convert them to plant tissue. When these plants die, some of these materials remain in the partially decayed plants and are deposited as peat or muck. The remainder is recycled by bacteria and fungi that convert the nitrates from decaying plants to gaseous nitrogen that is released into the air. Consider, for example, that in one study nearly 90% of the polluting nitrates deposited from surrounding farmland was removed by an Iowa marsh by the time the water had reached its outlet—and that this amazing feat of filtration was accomplished primarily by cattails and bulrushes!

Excess nutrients and polluting chemicals are also filtered out by becoming locked to particles of sediment in a process called ion exchange. These sediments (which include silt, sand, and soil particles of various sizes) settle quickly to the bottom of the wetland floor, taking the pollutants out of circulation. In addition, silt (soil particles of uniform size)—when suspended in water flowing through tangled, dense growths of wetland plants—is physically slowed or trapped and eventually settles to the bottom.

Wetlands with main channels or rivers cutting through them operate as filters in ways that differ from the filtering

action of wetlands such as marshes and bogs with no channels. Many midwestern wetlands encompass rivers that wander slowly through broad floodplains with numerous ponds, oxbows, and sloughs **(Slides 17 and 18)**. During flooding, water covers much of the floodplain, and the river becomes a slow-moving lake in which some pollutants are trapped by soil particles and settle out. Other pollutants may be absorbed directly by wetland plants or filtered out as water seeps down through the wetland soil to become groundwater. Floodplain wetlands, therefore, act as a buffer between the main channel of the river and the surrounding agricultural and urban landscapes. The removal of these buffering wetlands by drainage or channelization or by straightening the main channels of the river disrupts this remarkable filtering system and allows pollutants to enter the river. A recent government report described widespread herbicide contamination of the Mississippi River and its tributaries and associated wetlands each spring because of runoff from agricultural land. In 27% of the samples, levels of atrazine (a common herbicide used in growing corn and known to cause liver and kidney problems) exceeded the maximum levels allowed by the Environmental Protection Agency in drinking water.

Wetlands without channels—such as sedge meadows, marshes, and bogs—filter pollutants without the benefit of flooding from a nearby river. These habitats generally contain organic soils and are therefore good pollution traps. Peats and mucks have excellent filtering capabilities and attract polluting chemicals. Wetlands that are very shallow (less than a foot deep) and that have a widely spread flow pattern allow pollutants to come into maximum contact with the soil surface and are, therefore, highly efficient filters. But even these forgiving wetlands have their limits. The addition of any pollutant has a deleterious effect on habitat, even when that effect—for example, accelerated plant growth—seems innocuous at first. Plant species, such as cattails, that are adapted to use these excess nutrients begin to thrive and soon become dominant. As a result, species diversity is reduced, and the quality of the wetland as wildlife habitat is seriously impaired.

Wetlands also play a significant role in flood control and are valuable during drought years as well. Wetlands reduce flood peaks because they store rainfall and then slowly release it. During drought years, marshes and other wetlands feed stored water back into rivers and thereby help to maintain adequate water levels.

Flood damage in the Midwest for any given year, however, can be staggering. The Illinois River, for example, has experienced devastating floods at least once each year since 1978. Although millions of dollars are spent on dams and levees, flood damage continues to increase.

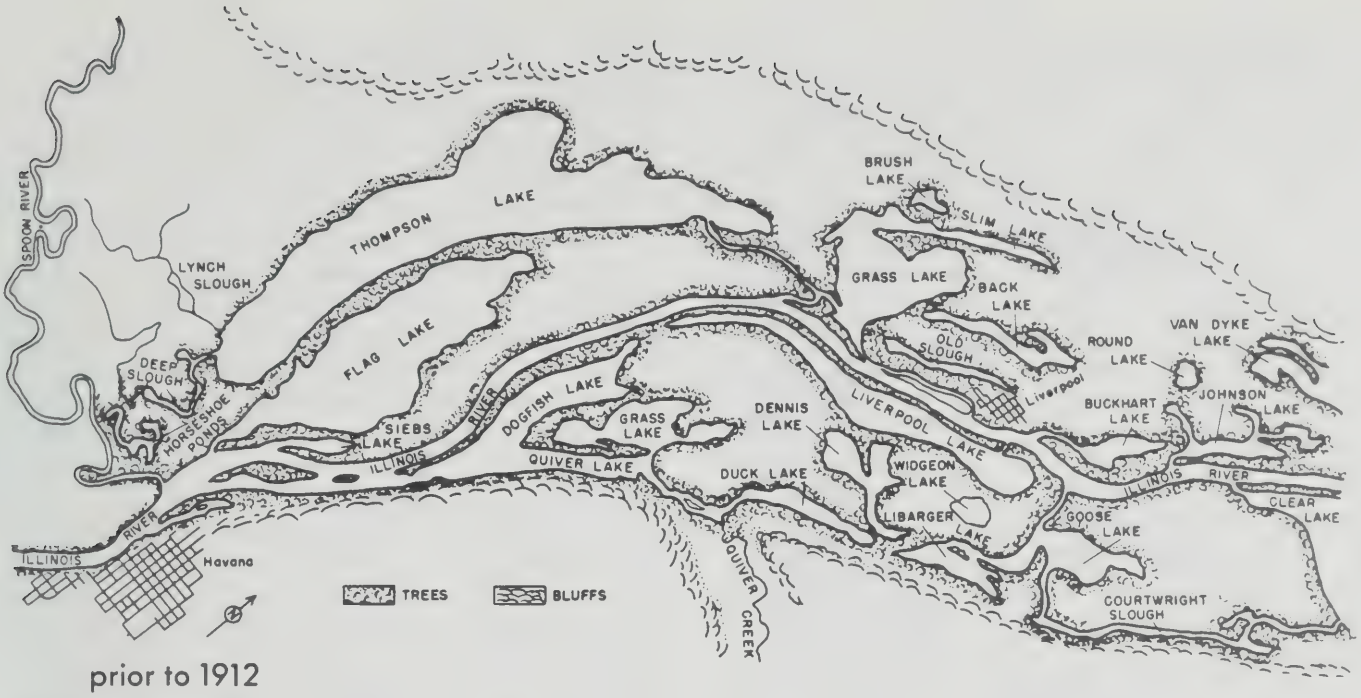
The main cause of the increase in flooding is the destruction of floodplain wetlands—nature's sponges—that store excess water and then slowly release it. In Illinois, for example, the Illinois River once encompassed nearly 400,000 acres of wetlands that could potentially flood yearly. By 1926, nearly half of those acres had been drained, leveed, and converted to farmland. Much of the water that originally spread over these broad floodplains now flows down the main river channel and contributes to flooding downstream. Flood control can be achieved only by giving back to the river some of the floodplain we have taken from it.

Straightening a river or stream has a detrimental effect on the filtering capabilities of its wetlands and on flood control. Water runs faster in straightened streams, allowing less time for sediment and pollutants to settle out or be removed by vegetation. Straightened, denuded streams also allow for virtually no absorption and storage of excess water, thus promoting flooding downstream. For wetlands to serve their biological functions of filtration and flood control, they must be preserved intact, not leveed, drained, straightened, or stripped of their natural vegetation.

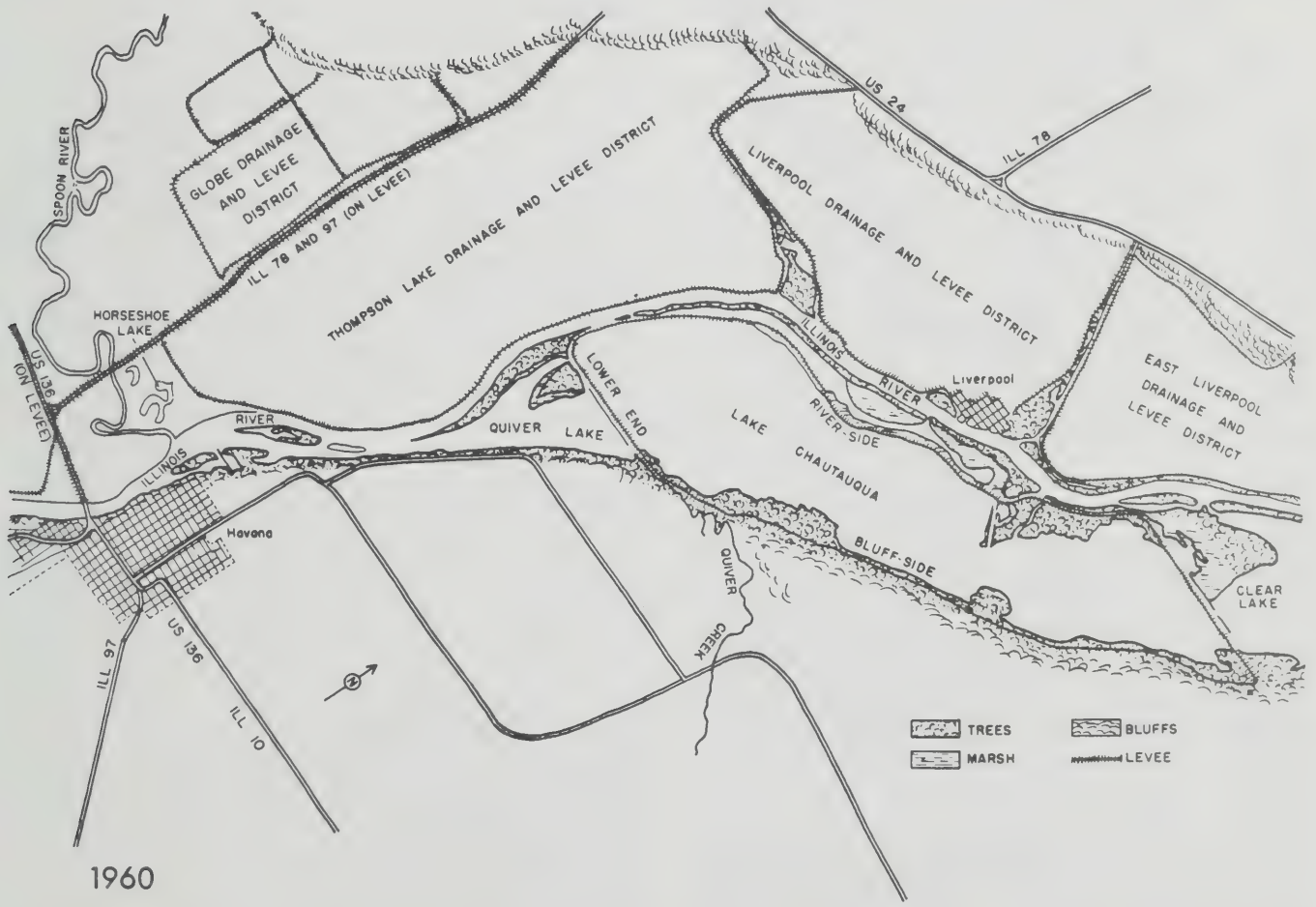
Another function of wetlands is to provide habitat for wildlife and to support an incredible diversity of species. Acre for acre they are the most productive temperate (nontropical) ecosystems. More plant material is produced in a marsh in the form of cattails and bulrushes than in a cornfield! This tangled mass of luxuriant growth is used all year long by wildlife for food, cover, and nesting habitat. Wetlands provide rookeries for wading birds such as the great and little blue herons and nesting or feeding sites for songbirds, raptors, and various mammals **(Slide 19)**. Wetlands are important nurseries for aquatic life and support both common and rare species, from the familiar green sunfish to the unusual banded pygmy sunfish. As the marshes, bogs, and fens have disappeared, however, so has the wildlife. Some species have simply declined in numbers, but others, such as the whooping crane and trumpeter swan, have ceased to nest in the Midwest and nearly ceased to exist as species altogether. Today wetlands are home to about one-third of all plant and animal species that have been recognized as threatened or endangered.

The price we and future generations pay for the loss of a species can never be known. Even a tiny spider may prove to have incalculable economic value. Scientists in Utah and Illinois have recently announced that an environmentally safe pesticide has been developed using a genetically engineered spider-toxin gene. In nature, an insect would receive the toxin via the spider's venom. In the laboratory, scientists have added the cloned toxin gene of the spider to a naturally occurring virus known to be modestly effective in the control of leaf-eating insects. The virus can then produce the toxin internally. When an insect eats the virus, the insect becomes paralyzed and dies. If further developments prove successful, an environmentally safe pesticide will be available for major row crops such as corn and cotton. A variety of natural toxins hold promise in the search for safe pesticides, but scientists will require the full repertoire of plants and animals. A lost species may be a lost opportunity.

From an aesthetic point of view, the appeal of wetlands cannot be measured in dollars and cents; yet to many people this aesthetic value is the most important of all. Wetlands are beautiful. There is a mystery about them—a great blue heron trying to eat a water snake it has caught but that is entwined

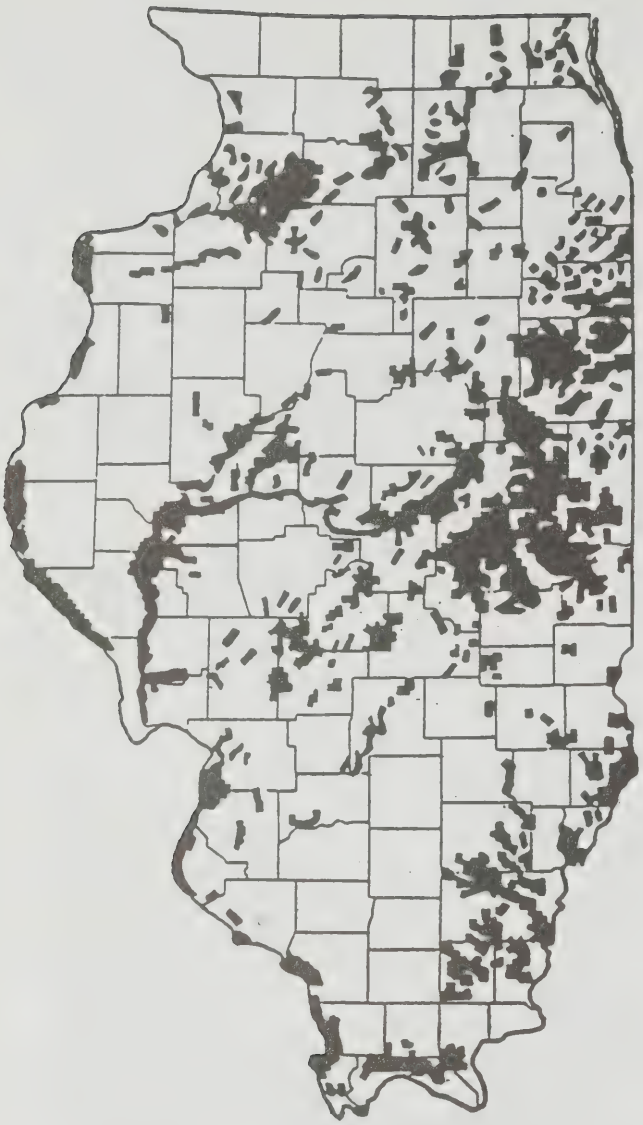


prior to 1912



1960

The natural condition of the Illinois River valley as it appeared in 1912 is seen in the top drawing. Note the numerous bottomland lakes with the main river channel cutting through. The bottom drawing shows the identical stretch of the valley after leveeing and draining to produce agricultural land.



Organized drainage and levee districts in Illinois before 1941.

around its beak, a raccoon patiently trying to solve the riddle posed by a tightly closed mussel—that generates excitement, even awe, in the observer. Wetlands are part of our natural heritage, sites for seclusion and reflection as well as for more active types of recreation like canoeing and photography. These wetlands, though characterized by an English journalist in the 1860s as "cheerless, miserable places, sacred to the ague and fever," are now recognized to have irreplaceable economic, ecological, aesthetic, and philosophical value.

Wetland Status Report

Estimates suggest that during the 1600s more than 200 million acres of wetlands were found in what was to become the lower 48 states. Since then, over half of those wetlands have been drained and converted to farms. Estimates made in the 1980s indicate that only 103 million acres of wetlands remain. In much of the Midwest, wetlands continue to exist only because these remnants are considered too difficult or expensive to drain or because the land to be recovered is deemed not worth the effort. Such areas are often used by landowners for hunting and fishing. In relatively few cases are wetlands intentionally preserved because their value has been recognized.

Illinois provides a stunning example of how humans have changed the landscape. After the last glacier receded, there were approximately 8.3 million acres of wetlands in what is now Illinois. Today, only about 1 million acres remain, and only 6,000 acres are undisturbed. Most were drained between 1879 and 1930 to reap the enormous economic benefits they offered. In the pursuit of tillable land, settlers often drained areas that would better have been left in their natural state. Indeed, in later years some of the floodplains that had been drained for row crops reverted to their undrained state when frequent flooding made agriculture unprofitable.

By the 1920s, most of the artificial drainage of Illinois wetlands was complete, and by 1937 nearly 750,000 acres of river bottomland had been incorporated into drainage districts. These districts, made legal by the Drainage Levee Act and the Farm Drainage Act of 1879, allowed landowners to pool their financial resources to drain land. Of the 35 million acres of Illinois, more than 17% is now part of organized drainage districts, and more than 27% of the state's agricultural land is drained in one fashion or another. When urban and industrial development are added to the story, we find that more than 90% of the original wetlands of Illinois have been destroyed. Iowa, like Illinois, has only a fragment of its native wetlands left, about 27,000 acres.

Although the recent history of our wetlands is bleak, we dare not assume that the final chapter has been written. Restoration is feasible, especially when sites are chosen carefully. Preservation is also possible; and if the remaining undisturbed sites are small, a slow but steady linkage of some of them is plausible. In fact, small wetlands may have greater ecological integrity than larger, disturbed ones. Ecological integrity simply means that a substantial percentage of the wetland species remains relative to the number that occurred there when the area was pristine. Thus, these small areas of diversity can serve as epicenters for the reinvasion of plants and animals into much larger areas undergoing restoration. In the meantime, they act as habitat corridors through which wildlife move in their search for adequate food and cover.

Preservation and Restoration

More than 117 million acres of wetlands have been lost in the lower 48 states since colonial times—more than half of the original wetlands. Ten states have lost more than 70% of their wetlands, and the loss continues at the astonishing rate of 60 acres an hour. What can be done to halt or even reverse this trend? Although federal, state, and local laws protect some wetland habitats, these laws do not provide adequate protection. They are riddled with loopholes, and their enforcement is hampered by inadequate staffing and a lack of funds.

Perhaps the best and most comprehensive protection comes from Section 404 of the Federal Water Pollution Control Act Amendments, legislation that authorizes the U.S. Army Corps of Engineers to require permits for the disposal of dredged or fill material onto an adjacent wetland or into any stream with an average flow of at least 5 cubic feet per second. Typical activities that require permits are the installation of pipes and the construction of levees, rip-rap, piers, boat ramps, canals, dams, dikes, roads, and artificial islands. A request for a permit can be denied if an alternative less harmful to the environment can be found or if the activity will cause "significant degradation" of an aquatic ecosystem. Significant degradation includes violations of toxic waste discharge standards, decisions that jeopardize threatened and endangered species or harm the ecology of an individual species, and actions that threaten the diversity and stability of an aquatic ecosystem.

Although the 404 permit system is better than no regulation at all, it does not provide adequate protection because wetlands can be drained or dredged as long as the material is not deposited in a wetland. Paradoxically, the law regulates the disposal of dredge but not its removal. In addition, small projects are often approved because individually they appear to cause little harm. Cumulatively, however, they chip away at the wetland resource and ultimately may have the same impact as a few large, more obviously destructive projects.

The Soil Conservation Service is also involved with wetlands. The "Swampbuster" Provisions, enacted in 1985, made any farmer that grew a crop on any wetland converted after 1985 ineligible for federal farm program money the year the crops were grown. Because farmers could still convert wetlands and then grow crops on them only in years when crop prices were high and the farmers did not need federal aid, a 1990 law added a new provision. It made farmers who convert wetlands into cropland after 1990 ineligible for federal farm programs.

Other laws that help to protect wetlands include the Federal Endangered Species Act of 1973, a law that protects species but in actuality does little or nothing to protect habitats, and Section 10 of the River and Harbor Act, a regulation that requires permits for projects on, in, or above any navigable waters of the United States. To a lesser extent, floodplain zoning offers some protection to wetlands in the 100-year floodplain (the maximum area that a given stream can potentially flood once in a hundred years) by preventing filling and construction that interfere with the discharge of floodwater. In addition, wetlands can be protected by public acquisition. Examples in Illinois include the Mark Twain and Upper Mississippi Fish and Wildlife Refuge and the Lower Cache River Bottomland Swamp. The first is owned and managed by the U.S. Fish and Wildlife Service, the latter by the Illinois Department of Conservation.

So what is the job before us? Where the preservation of wetlands—indeed, of all natural habitats—is involved, we must be uncompromising. We can afford to lose no more. Back in 1949, Aldo Leopold wrote in his foreword to *Sand County Almanac*, "Like winds and sunsets, wild things were taken for granted until progress began to do away with them. Now we face the question of whether a still higher 'standard of living' is worth its cost in things natural, wild, and free" **(Slide 20)**. Half a century of "progress" later, an "enlightened" technological age is not much further along in solving environmental problems, including the destruction of wetlands. We continue to hear reports of yet another "fragile" ecosystem destroyed in the name of development, and the term *environmental tradeoff* has entered all too frequently and dangerously into political rhetoric. Biologists know that unaltered ecosystems are not inherently fragile but are extremely stable and sturdy. The problem is that human disruptions of these ecosystems are often massive and result in serious, frequently irreversible harm.

Both streamside and unchanneled wetlands can be restored. All that is needed is a source of water and a place for it to accumulate. Much of the agricultural land in central Illinois, for example, would revert to its former wetland state if field tiles and levees were removed. Wetland restoration is obviously not that simple, but the requisites are surprisingly attainable: a site with an adequate source of groundwater or surface water, a slope that will broaden the zone for emergent plants, and a source of native wetland plants for establishment.

One of the most important ways in which individuals can help to preserve wetlands is by becoming involved in formal and informal education efforts. To know our environment, we must observe it and achieve a certain intellectual, emotional, and physical intimacy with it. In the Midwest, conservation organizations abound, each with its own agenda but all ultimately working to preserve natural diversity. Many of these groups are interested in wetland preservation and provide workshops, slideshows, field trips, newsletters, and legislative alerts. The Nature Conservancy, Sierra Club, Audubon Society, Izaak Walton League, and Ducks Unlimited, for example, have long and illustrious histories of preserving natural habitats and are powerful voices in the conservation movement. In addition, under the framework of the North American Waterfowl Management Plan, the United States and Canada are seeking to protect more than 6 million acres of important wetlands in both countries. For more information about these and other environmental organizations, contact your public library.

Taxpayers and voters, especially those who have wetlands on their property, need to be informed about the benefits of wetlands and the need to preserve and restore them. But perhaps the most crucial group to reach are our youngest citizens—the future guardians of our wetlands. Through their earliest exposure to science on up through high school and college courses and through organized activities like 4-H, FFA, and Scouting, tomorrow's voters can become articulate advocates for wetlands and an informed political force. It is to the mentors of that youthful audience that this publication is directed.

Part Two: Twelve Activities for Young People

The dozen activities that follow rely on a simple format. Each includes an instructional objective, a list of skills emphasized in the activity, a list of materials needed, a detailed procedure for carrying out the activity, and a suggested evaluation. Vocabulary to be introduced and comments to the instructor are also provided in most instances. Some activities rely on student handouts, and copies suitable for reproducing are included. Slides that might be shown during a given activity are also noted.

Teachers have several options in deciding how to use these activities. They may be used consecutively and in their entirety as an independent wetlands unit in the science curriculum. Alternatively, individual activities can be used as supplementary material within larger science units already in place. Some—such as Discovering Beauty in the Muck and Mud, and Who Decides the Future of Wetlands?— can be incorporated into the language arts curriculum, as can several of the writing assignments used as evaluations. Others, especially those related to political attitudes and community values, can be scheduled during the social studies period.

These activities were written with middle school youngsters in mind, but they can be adapted for younger or older students. Teachers, of course, are the best judges of whether their students have the background to complete a given assignment successfully. Although the activities follow a logical sequence based on content, they have not been arranged in order of difficulty.

A glossary of the vocabulary introduced in the activities is included, as are instructions for constructing some of the equipment used during a wetlands field trip. Additional information can be found in the bibliography, "Learning More about Wetlands."

Activity One: How Do I Know a Wetland When I See One?

OBJECTIVE to become familiar with the criteria scientists use in determining whether an area is a wetland and to apply these criteria in a wetland inventory

SKILLS classification, comparison, data analysis, generalization, inference, map reading, plant and animal identification, determination of spatial relationships

VOCABULARY adaptation, bedrock, botanical, groundwater, hydric soil, hydrology, inventory, runoff, soil type, subsoil, surface water, uplands, water table

MATERIALS copies of **Inventory Sites: Description**, **Inventory Sites: Keys**, and **Final Report: Biological Survey for Wetland Determination**

COMMENTS In response to the dramatic loss of wetlands throughout the United States, scientists are attempting to gather detailed information on the remaining wetland habitats. Included in this undertaking is a comprehensive inventory of wetlands that assesses their current status and the requirements for their preservation. In this sense, an inventory is an organized effort to locate, characterize, classify, and evaluate a potential natural wetlands. In this exercise students use a simplified version of such an inventory to determine whether an area in question is indeed a wetland. Students will need to be familiar with the information given in Part One under the following headings: What's a Wetland?, Water Work, and Flora and Fauna. Be sure students understand the terms *hydric soil* and *hydrology*.

The part land and part water character of a wetland with wet soil and emergent and submerged vegetation.

PROCEDURE 1. Present the related material from Part One, emphasizing the characteristics that determine whether an area is a wetland, including soil type, water supply (hydrology), and plant populations. You may also wish to show the slides referred to in these sections. In addition, slides 11 (bald cypress) and 16 (arrowhead) are appropriate. Don't hesitate to add information from textbook and library resources.

2. Distribute copies of the three handouts that accompany this exercise to every student or to each group of students working as a team. One copy of **Inventory Sites: Description** and **Inventory Sites: Keys** and three copies of **Final Report: Biological Survey for Wetland Determination** will be needed by each team or individual.

3. Develop the following scenario in an informal but realistic manner. Each student or team either represents an environmental consulting firm or a scientific agency charged with determining whether three sites are wetlands. Their final reports should be based on the scientific evidence available and on informed judgment.

4. After students have studied the three site descriptions, they complete the three final reports and decide which of the sites in question should be classified as wetlands. Remember, this inventory is not a test but a way of opening discussion about what makes a wetland.

5. Later, discuss the site classifications. How many students came to similar conclusions in their final reports? What were the bases for their decisions? Why were different conclusions sometimes reached? Note that while the water table in site 1 changes throughout the year, it is high enough during certain seasons, combined with surface runoff from the uplands, to support water-loving cattails and water lilies in the basin. Hydric soil is present. In site 2, the presence of several water-loving plants, including the buttressed bald cypress, should be noted. Although less runoff occurs in site 2 than in site 1, the clayey soil helps to hold the water for a longer time. The water table in site 2 is the primary water source. Hydric soil is present. In Site 3, the mere presence of cattails is not enough to label the area a wetland. Because no floodplain has formed, only a steep-sided stream with narrow banks, there is little habitat for large populations of typical wetland plants. No hydric soil is present.

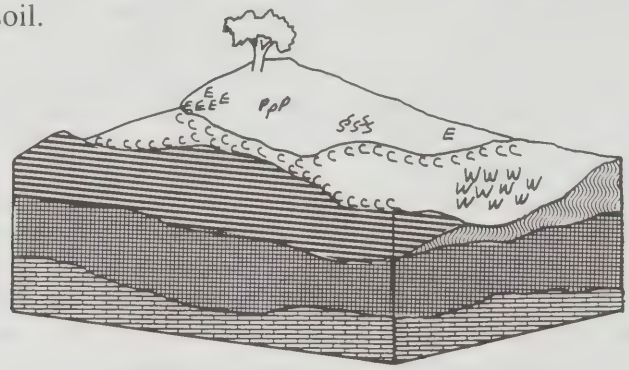
EVALUATION Ask students to write a paragraph defending one of the following propositions:

1. The presence of water is not necessarily the best criterion for determining whether an area is a wetland.

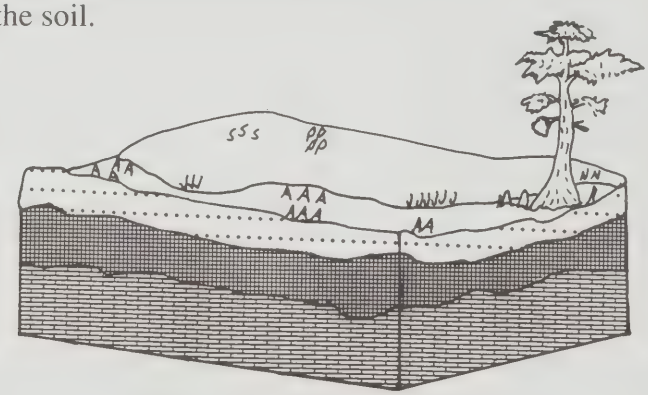
2. A botanist is well equipped to determine whether a given area is a wetland.

Inventory Sites: Description

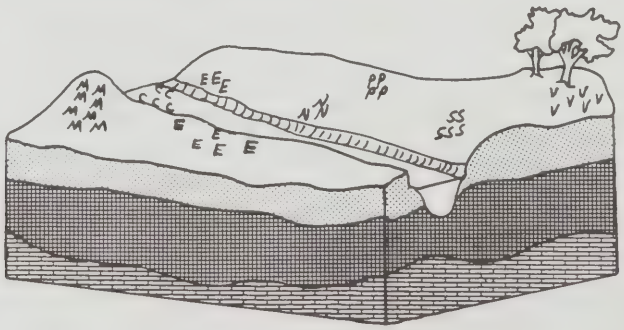
Site 1. The water table changes quite frequently due to heavy spring and fall rains and ranges from 3 to 15 feet below the surface. Runoff from uplands is heavy. The depression is lined with sand and loses water rapidly through the soil.



Site 2. The water table changes very little over the year and averages 3 feet below the surface. There is somewhat less runoff from the surrounding land than in site 1. The bottom of the depression is clayey and slows water loss through the soil.



Site 3. This area has a permanent stream; its level varies with the season. In midsummer, as pictured here, the stream level is relatively low and corresponds to the water table. Over the years the stream has eroded down and formed a relatively steep-sided channel.



Hints: Other Indicators of Wetlands

Other indicators of wetlands include trees with large bases (buttressed trees), trees with knees (knees help the roots to obtain air), and plants with floating leaves.

KEY TO PLANT SPECIES

Must live in water for most of the year

arrowhead (A)

water lily (W)

cattail (C)

Usually live in wet soil

jewelweed (J)

wood nettle (N)

blue lobelia (L)

Usually live in uplands but can live in wet soil

evening primrose (E)

phlox (P)

spiderwort (S)

Always live in uplands

common milkweed (M)

bird's-foot violet (V)

KEY TO SOIL TYPES

Upland soil

Hydric soils

Subsoil

Bedrock

Final Report: Biological Survey for Wetland Determination

Site number_____ Survey conducted by_____

Summary of Findings

1. *Botanical survey*. List the species of plants found and where they were found. Note which were dominant or most abundant.

2. *Hydrology*. What is the source of the water (for example, groundwater, precipitation, runoff from surrounding land, floodwaters)? During what season(s) of the year would standing water probably be present?

3. *Soils*. What type of soil is present at the surface?

Final Determination

Is this area a wetland? Yes___ No___

On what basis did you make this decision?_____

_____

_____

_____

_____

Activity Two: The Food Web

OBJECTIVE to understand the relationships within a simple wetland as expressed in a food web

SKILLS analysis, classification, comparison, deduction, inference

VOCABULARY amphipod, carnivore, copepod, detritivore, detritus, ecosystem, food chain, food pyramid, food web, herbivore, omnivore, phytoplankton, primary consumer, primary producer, secondary consumer, top carnivore, trophic

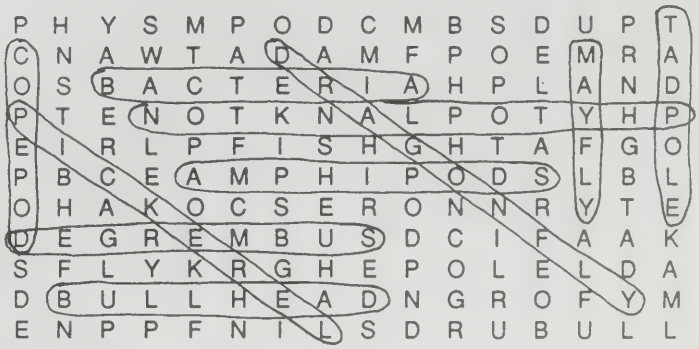
MATERIALS copies of **Wetland Ecosystem**, **Wetland Organisms**, and **Marsh Menus**; scissors, paste, and pencils; unlined paper or poster board

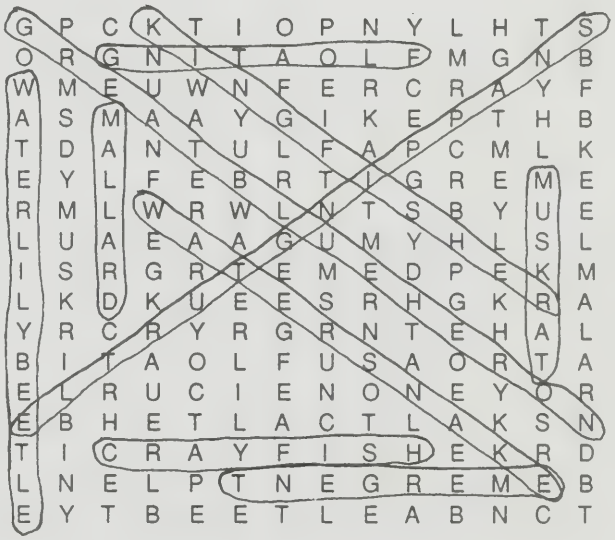
COMMENTS Before beginning this exercise, introduce the concepts of food chain, food web, and food pyramid by sketching out several examples on the chalkboard. The information in Part One should get you off to a good start. Make sure students are familiar with the terms associated with these ecological concepts. Remember to point out that some organisms feed on more than one trophic level. The snapping turtle, for example, is classified as a carnivore, but it sometimes eats plants. The completed food webs may look complex, but the concept is relatively simple. The answers to the word search puzzles are given to the right.

PROCEDURE 1. Conduct a preliminary poll by asking students what types of plants and animals they would expect to find in wetlands. Make a composite list of their suggestions on the chalkboard.

2. Distribute copies of **Wetland Ecosystem**. Here students will find the names of 20 organisms that are hidden in two word search puzzles. Ten strictly aquatic organisms and 10 organisms that spend part or all of their life out of the water are found in separate puzzles. The names of the organisms are hidden according to four trophic categories: primary producers, primary consumers (herbivores), secondary consumers (carnivores), and detritivores. In each puzzle the names of primary producers are printed horizontally from right to left, the names of primary consumers are printed vertically, the names of secondary consumers are printed diagonally, and the names of detritivores are printed horizontally from left to right.

3. When students have circled as many names of organisms as they can find, they should list them by trophic category in the space provided. If you prefer, categorize the 20 organisms with the class by making a master list on the chalkboard.





4. Distribute copies of **Wetland Organisms** and **Marsh Menus**. You may read the story aloud before continuing this activity or ask students to read it silently. Emphasize that the story presents a relatively simple example of a food web.

5. Ask each student to use the pictures from **Wetland Organisms** to construct a food web based on the story, on information learned from the word search puzzles, and on their own experiences and observations. Students may supplement the pictures you have provided with drawings of their own or complete the entire web with their own artwork. They should also be encouraged to add their own ideas to the food web described in the story. An example of a simple food web is given in Part One in the section titled Chains,

Webs, and Pyramids. Be sure that students understand that the arrows they draw between organisms indicate what eats what in the food web and always point in the direction of energy flow. If, for example, a water snake eats a pickerel, the water snake takes energy from the pickerel: pickerel —> water snake. Be sure that students understand that several of the animals in the story feed on organisms from different trophic levels and are classified as omnivores.

6. Discuss the completed food webs, pointing out differences and noting the changes that the introduction of an organism makes. What are the top carnivores in this food web? Which organisms have the most arrows leading to them? From them? What does the pattern of arrows tell us about the overall functioning of the food web? What happens to a food web when it is broken by the elimination of one or more organisms? What might happen if a poisonous chemical entered the water in a marsh and was taken up by the plants? Would the carnivores escape? Why or why not?

7. Summarize the activity by reproducing a wetland food web on the chalkboard following instructions given by the class. Point to various organisms on the food web and ask students to identify whether a given organism is a primary producer, primary consumer, herbivore, carnivore, secondary consumer, detritivore, or omnivore.

EVALUATION Ask each student, perhaps as a homework assignment, to write a wetlands story that could be used as the basis for a food web. The story should include herbivores, carnivores, omnivores, and detritivores. You will want to evaluate these stories yourself and share some of them with the class, but it might also be fun to appoint a committee of students to choose three or four of the stories to be used by the class to create other wetland food webs. These webs might be done as posters and displayed beside the stories that inspired them.

Wetland Ecosystem

Aquatic Organisms

phytoplankton
submerged (plants)
copepod
mayfly (nymph)
tadpole
pickerel
dragonfly (nymph)
bacteria
amphipods
bullhead (catfish)

P	H	Y	S	M	P	O	D	C	M	B	S	D	U	P	T
C	N	A	W	T	A	D	A	M	F	P	O	E	M	R	A
O	S	B	A	C	T	E	R	I	A	H	P	L	A	N	D
P	T	E	N	O	T	K	N	A	L	P	O	T	Y	H	P
E	I	R	L	P	F	I	S	H	G	H	T	A	F	G	O
P	B	C	E	A	M	P	H	I	P	O	D	S	L	B	L
O	H	A	K	O	C	S	E	R	O	N	N	R	Y	T	E
D	E	G	R	E	M	B	U	S	D	C	I	F	A	A	K
S	F	L	Y	K	R	G	H	E	P	O	L	E	L	D	A
D	B	U	L	L	H	E	A	D	N	G	R	O	F	Y	M
E	N	P	P	F	N	I	L	S	D	R	U	B	U	L	L

Other Wetland Organisms

emergent (plants)
floating (plants)
mallard (duck)
muskrat
water lily beetle
kingfisher
water snake
great blue heron
snapping turtle
crayfish

G	P	C	K	T	I	O	P	N	Y	L	H	T	S
O	R	G	N	I	T	A	O	L	F	M	G	N	B
W	M	E	U	W	N	F	E	R	C	R	A	Y	F
A	S	M	A	A	Y	G	I	K	E	P	T	H	B
T	D	A	N	T	U	L	F	A	P	C	M	L	K
E	Y	L	F	E	B	R	T	I	G	R	E	M	E
R	M	L	W	R	W	L	N	T	S	B	Y	U	E
L	U	A	E	A	A	G	U	M	Y	H	L	S	L
I	S	R	G	R	T	E	M	E	D	P	E	K	M
L	K	D	K	U	E	E	S	R	H	G	K	R	A
Y	R	C	R	Y	R	G	R	N	T	E	H	A	L
B	I	T	A	O	L	F	U	S	A	O	R	T	A
E	L	R	U	C	I	E	N	O	N	E	Y	O	R
E	B	H	E	T	L	A	C	T	L	A	K	S	N
T	I	C	R	A	Y	F	I	S	H	E	K	R	D
L	N	E	L	P	T	N	E	G	R	E	M	E	B
E	Y	T	B	E	E	T	L	E	A	B	N	C	T

Primary Producers Herbivores Carnivores Detritivores

Wetland Organisms

Marsh Menus

On a warm, muggy summer day the sun shines on a vast expanse of marsh, providing energy for green plant growth, both above and below the surface of the still water. These plants are food for a number of animals. Large, floating lily pads are eaten by water lily leaf beetles. Below the surface mayfly nymphs graze on submerged plants and on the smaller plants (phytoplankton) that grow on the surfaces of the submerged plants. Tadpoles and copepods (nearly microscopic crustaceans related to shrimp) also rely on these phytoplankton for energy.

In time, these large and small plants, along with other organisms, die and sink to the bottom of the marsh where bacteria and fungi decompose them into a rich layer of detritus (decayed plant and animal parts). This detritus provides food for many other organisms, including green plants, crayfish, bullhead catfish, and small crustaceans called amphipods.

Other grazers in the marsh include mallards, which eat large quantities of seeds from aquatic vegetation and supplement their diets with mayflies, amphipods, and even an occasional tadpole. Muskrats feed mostly on larger plants but eat crayfish when they can catch them.

Silent but deadly predators lurk in the shallows. The snapping turtle eats just about anything it can fit into its cavernous mouth—from mallard ducklings and young muskrats to various fish and, occasionally, submerged plants. On a smaller scale, dragonfly nymphs use their unusual mouthparts to capture crustacealike copepods and amphipods, mayfly nymphs, and even a young pickerel. A larger pickerel soon returns the favor and makes a meal of the dragonfly along with its normal fare of tadpoles and various small crustacea. Every fish in the marsh, though, must beware from above as well as below! Pickerels and bullheads make tasty morsels for kingfishers and herons, and certain water snakes live mostly on fresh fish. But even the water snake is not safe. The heron, like the snapping turtle, will catch and swallow just about anything that fits down its throat.

Activity Three: What's Disturbing about a Disturbed Wetland?

OBJECTIVE to deduce the effects of humans on wetlands and to manipulate food webs to reflect those effects

SKILLS deduction, discerning cause and effect relationships, making inferences

VOCABULARY erosion, sediments (sedimentation), toxic

MATERIALS three or four erasable transparencies of one or more of the food webs from the preceding exercise to be used with an overhead projector. If you prefer, you may draw the webs on the chalkboard. To complete the evaluation, you will need paper suitable for a mural, paste, scissors, and colored pencils or crayons.

COMMENTS The impact of humans on wetlands reached epic proportions during the last quarter of the 19th century and has continued throughout most of this century. Wetland habitats have been destroyed by any means deemed appropriate to further urban, industrial, and agricultural development. Pesticides leached from surrounding agricultural land have entered the food chain, often with devastating effects on nontarget organisms such as ospreys and eagles, and have been deposited in sediments, further toxifying the environment and often causing "mysterious" dieoffs of mussels and fish. Altered streams rush between high levees, sending loads of floodwater downstream; their associated wetlands, once breeding grounds for large numbers of aquatic organisms, have become cornfields. Generations of hunters have adversely affected waterfowl populations, not so much by direct kill but by the indirect effects of spent lead shot pellets deposited on the bottoms of lakes and marshes. In most cases, ducks die after swallowing lead pellets. The only solution to wetland destruction appears to be to "just say no" to further destruction. (Note: Since 1991 it is illegal to use lead shot for waterfowl hunting in the United States.)

Because ospreys are at the top of the food chain, they can receive particularly high amounts of accumulated pesticides.

PROCEDURE: 1. Introduce this activity by relating examples of how we have intruded into wetlands in highly destructive ways. Some ideas are given in the comments above and others are provided in Part One, especially in the sections titled Wetland Benefits and Wetland Status Report. Emphasize that the magnitude of the damage we have done is not so much because wetlands are delicate or fragile ecosystems; actually, they are surprisingly sturdy and resilient. Rather, the damage is to be explained in terms of the magnitude of our interventions and the subtle and complex interrelationships among the plants and animals in any ecosystem.

2. Describe in your own words the situation outlined in Scenario A below. Expand on the bare-bones description given there by including material from Part One. Tailor the scenario to fit the food web you are going to use at the chalkboard or as a transparency. Ask students how you must now alter the food web to reflect the human disturbance. Begin by erasing organisms that are likely to be killed by the disturbance as well as the energy lines flowing to and from those organisms. Ask for comments on how the surviving organisms are likely to be affected. What happens when a food web is out of balance?

Scenario A. With current farming practices (fall plowing, for example, which leaves the soil exposed to the erosive effects of wind and water, as opposed to conservation tillage, which leaves the stubble in the fields to hold the soil over the winter months), large quantities of soil are washed from agricultural fields into wetlands and their adjacent streams and rivers. Illinois, in fact, loses 3.3 pounds of topsoil for every pound of corn and soybeans it produces. When the soil reaches the wetlands, it clouds the water (called turbidity), thereby reducing light penetration and inhibiting plant

Pesticides and herbicides washed from farm fields can kill aquatic animals and alter plant growth in streams and rivers.

Since 1991, it has been illegal to use lead shot for waterfowl hunting in the United States.

growth. About half of the soil settles to the bottom, changing the character (including depth) of rivers and lake beds. Now there is a homogeneous bottom of sediments rather than a varied bottom with areas of mud alternating with stretches of sand and gravel that provide spawning beds for many aquatic species. These sediments also contain fertilizer and pesticides and herbicides that have washed from farm fields. These chemical residues can kill insects and alter plant composition by eliminating some species and by accelerating the growth of others. Finally, where does the remainder of the eroded soil go? Ultimately to Louisiana! The eroded soil moves from fields to creeks and streams and on to Illinois rivers, ending up as a muddy flat at the mouth of the Mississippi River.

3. Repeat step 2 using Scenario B and beginning with a fresh transparency or a redrawn food web on the chalkboard. You might try using a red pen or colored chalk to trace the path of lead as it moves up the food chain.

Scenario B. Spent lead and steel shot from the guns of waterfowl hunters are often found in large quantities in wetlands. Lead shot is toxic (poisonous); steel shot is not. Waterfowl eat shot while feeding and become sick and die if the shot is lead. Because lead lasts a long time and is toxic to most organisms, it remains in the food web and affects other organisms as well.

4. Combine scenarios A and B. What is their combined effect on a wetland food web?

EVALUATION Have students work together to construct a large mural depicting an undisturbed wetland food web and at least two versions of that web showing what happens when human activities disturb a wetland. Pictures for the mural may be drawn by students, or their drawings may be combined with those on **Wetland Organisms**, the handout used in the preceding activity. Photographs and illustrations gleaned from magazines like *National Geographic*, *Ranger Rick*, and *National Wildlife* may also be incorporated. When the mural is complete, ask students to provide a title for the mural as well as a few lines of explanatory text for each web.

If your classroom does not lend itself to a large group project, the evaluation may be completed by individuals or small groups, with the end product being posters instead of a single mural.

Activity Four: Acquiring a Wetlands Vocabulary

OBJECTIVE to master a wetlands vocabulary that will enhance the understanding of what a wetland is and how it operates

SKILLS memory, vocabulary acquisition, spelling

VOCABULARY Listed below are some of the specialized terms used in Part One and in the various activities. You may choose from the list the words most useful for your students. Of course you may add to this list to accommodate the scientific background of your students and to reflect the level of the wetland discussion in your class. Consider this an ongoing activity, one that should be used from time to time as new wetland words are introduced.

absorb
acid (acidic, acidity)
adapt (adaptation)
alkaline
amphipods
anaerobic
aquatic
backwater (bottomland) lake
basic
bedrock
biology (biologist, biologically)
botany (botanist, botanically)
carnivores
carrying capacity of an ecosystem
copepods
crustacea
decomposers (decompose, decomposition)
degrade (degradation)
detritivores (detritus)
ecological integrity
ecology (ecologist, ecologically)
ecosystem
emergent plants
entomologist (entomology)
environment
filter (filtration)
floating plants
flood plain
food chain
food pyramid
food web
groundwater
habitat
herbivores
hydric soils
hydrology
hydrophytes
inorganic soil
invertebrates
nutrients
omnivores
organism
oxbow pond (marsh)
pH (low/high)
photosynthesis
pollution (pollutants)
precipitation
primary consumers
primary producers
runoff
saturated
secondary (tertiary) consumers
sediment (sedimentation)
soil type
species diversity
submerged plants
subsoil
surface water
terrestrial
top carnivores
toxic
trophic
trophic pyramid
turbid (turbidity)
uplands
vertebrates
water table
wetland

MATERIALS 3" x 5" lined cards, scrap paper, pens or pencils, rubber bands

COMMENTS By the time you have completed the three preceding activities, students will have been exposed to a fairly large wetlands vocabulary. This exercise is designed to help students master those words—and others you may wish to add. Students cannot truly be said to understand wetlands unless they can use the specialized terms that describe and explain wetlands.

PROCEDURE 1. Divide the class into small groups of four or five students. Give each group a stack of 3" x 5" cards, scrap paper, and pens or pencils. Write the first wetland term you have chosen on the chalkboard, for example, *herbivore*. One student from each group prints that word on the reverse (unlined) side of a card; request clear and reasonably large printing. Now ask each group to define that word as fully as possible on a piece of scrap paper. Examples that help to define a term may be used, but only in connection with a legitimate definition. After a minute or two, share the definitions and work out a composite definition that represents the best thinking of the class. Write that definition on the chalkboard and have a member of each group copy it on the lined side of the card.

2. Proceed in this way until all of the terms you have chosen have been defined and recorded on cards. Collect the cards, putting a rubber band around each set.

3. Combine two sets of cards so that the same term will be defined more than once. Hold up a card, word side facing the class, and ask a student to pronounce and define the term. After a minute or two, any student in that student's group may correct, expand, or improve upon that definition. If the group has no additions or refinements, anyone in the class may suggest changes. Continue until all cards have been used. If the vocabulary you have chosen to present exceeds 10 or 15 words, you may want to extend this activity over more than one class period.

4. You can vary this activity or provide more practice by adapting a "Twenty Questions" format. Return the cards by set to each group. One person in each group begins the game by drawing a card but concealing it from others in the group. Members of the group then take turns asking questions about the word on the card until someone identifies the word. If you have devised a scoring system, you might give double points if the student who identified the word is also able to spell it correctly.

Groups may also review definitions by placing the set of cards in a box or large envelope. Each student in turn draws a card and without looking at it hands it to another member of the group who reads the word aloud. The student who drew that card then defines the term. The group decides whether the definition is acceptable.

EVALUATION After students have had reasonable opportunity to master the terms, reverse the procedure. Read each definition in turn, but be sure that you do not use the word itself in the definition. Ask students to write down the wetland word for which you have read the definition. Spelling counts!

Activity Five: Minimarvels

OBJECTIVE to learn some of the remarkable adaptations that insects have made to aquatic environments

SKILLS following directions, observation, deduction, comparison

VOCABULARY abdomen, anterior, entomologist (entomology), nymph, posterior, thorax

MATERIALS five wide-mouth glasses or jars, five needles, five forks, copies of **Minimarvel Insect Drawings**

COMMENTS The immediate reaction of most of us to a crawling or flying insect is to stomp or swat. Even the smallest of these creatures that we so often kill are remarkably designed and intricately structured animals. Down to the tiniest detail, their bodies are perfectly adapted for success within their complex ecosystems.

An insect's body is composed of three main parts: head, thorax, and abdomen. The head contains most of the sensory equipment such as eyes, antennae, and mouthparts. Mouthparts differ considerably in size and shape depending upon their functions. Some insects, for example, have piercing and sucking mouthparts for getting fluids out of plants or animals; other insects have chewing mouthparts for devouring prey or leaves; still others have sponging mouthparts for picking up fluids. The middle part of the body is the thorax. It houses the locomotor apparatus—three pairs of legs and in many insects one or two pairs of wings. The abdomen contains the sexual organs used in mating and egg laying and the organs for digestion and breathing.

How many insects are there? The exact number of species is unknown because many areas of the world remain to be studied by entomologists. Estimates vary considerably, but a guess of over one million living species is probably quite conservative. We do know, for example, that a quarter of a million species of beetles have been described and that 28,600 of them are found in the United States! In contrast, only 5,000 species of mammals are found on our planet. These numbers mean that there are at least 200 insect species for every species of mammal. A British entomologist once estimated that 1,000,000,000,000,000,000 (a billion billion) insects are alive at every instant. Insects outnumber people by at least 1,000,000 to 1, and the insect population outweighs the human population by at least 20 to 1.

Why have insects proved so successful? One reason is their small size, which lets them occupy habitats too small for other animals. In addition, their diminutive size allows them to survive and reproduce on small amounts of food. Another reason for their success is their short life cycle. An insect can utilize habitats or food resources that are available for only a short time. The success of insects also depends upon their ability to move from unfavorable sites to more favorable sites, often by flying. In addition, insects have an amazing potential for reproduction: a mayfly, for example, lays thousands of eggs during its brief adult life.

Where do insects fit into food webs? They are found almost everywhere above the level of primary producer, and the roles they play are crucial to the functioning of food webs. Insects feed on a wide variety of plants, aid in their pollination, and decompose dead organisms. In turn, insects are a major food resource for other organisms, including birds, amphibians, mammals, and other insects.

Entomologists study insects for many reasons, but the incredible number of species and their wide variety of colors, shapes, life histories, and sizes (from about 1/100 of an inch to 13 inches in length and from 1/50 of an inch to nearly 1 foot in wingspread!) interest us all.

PROCEDURE 1. Introduce this activity with information from the comments above and from other materials available in your classroom and library. You may want to review insect metamorphosis briefly if that is a subject with which your students are familiar. The minimarvel adaptations for wetland survival that are described below are divided into four categories: locomotion, feeding, breathing, and reproduction.

Typical wetland insects include a predaceous diving beetle (note its oarlike hind legs) and a caddisfly larva with a case made of sand.

Locomotion. The water strider, sometimes called a pond skater, does not float on water like a piece of wood. Instead, it skates on the surface. Its body is so light that its six legs do not break through the water's thin surface. Demonstrate how the strider manages this locomotory marvel with the following simple experiment.

Divide the class into five groups, providing each group with a glass of water, a needle, and a fork. Ask a member of each group to follow these instructions: Place the needle on the fork, hold the fork near the surface of the water, and let the needle gently roll into the water. The needle floats because the surface of the water is like a skin that supports the needle. Push on the needle with the fork, and the needle sinks because the water's "skin" has been broken. Allow a few minutes so that each student can perform the needle "trick." Some failures can be anticipated if students break the surface of the water with the fork.

Another remarkable form of water locomotion is used by the immature dragonfly or nymph. Although the adult dragonfly relies on its wings to get about, the nymph lives underwater and depends on a form of jet propulsion. It sucks water through the rear of its body into a chamber in its abdomen and then squirts it out with enough force to propel itself forward through the water.

Diving beetles swim underwater searching for aquatic insects and tiny fish to eat. Their hairy rear legs act like paddles to move them through the water.

Feeding. The adult dragonfly catches mosquitoes and other small insects while in flight, but the wingless immature nymph develops entirely underwater and must find another method of feeding. Nymphal mouthparts are hinged underneath the head and swing out like a retractable lower "lip" to snatch prey such as an aquatic insect, a small fish, or even a tiny tadpole.

The slender water scorpion uses its front legs to capture prey—just about any small underwater creature. Its needle-like mouthparts pierce its prey, and the water scorpion then sucks the juices from inside.

The water strider searches for insect prey on the surface of water and finds a menu suited to its ability to "skate" on the surface. Tiny waterproof hairs on its feet help to prevent it from sinking.

Breathing. Many water insects, such as the caddisfly, rely on gills for breathing. The water scorpion, however, has no gills and must poke its breathing tube up through the surface film of the water to get air. The gill-less diving beetle must go to the surface to get a bubble of air, which it holds under its wing as it re-enters the water. Other diving beetles rely on waxy hairs to trap air next to their bodies. The dragonfly nymph gets oxygen by pumping water into a chamber in its abdomen; expelling this water also provides locomotion.

Reproduction. The female of some species of water bugs takes care of her eggs by gluing them to the back of a male, which carries them until they hatch. Damselflies and dragonflies mate while in flight. The male grasps the female behind her head with the tip of his abdomen. The female collects sperm by placing the tip of her abdomen near the male's sex organs on the anterior (front) end of his abdomen.

2. After you have discussed the wetland minimarvels described above, distribute a copy of **Minimarvel Insect Drawings** to each student. At the chalkboard list the aquatic insects you have introduced. Ask students to help you compile this list: water strider, dragonfly nymph, diving beetle, caddisfly, water scorpion, damselfly, and water bug. With no hints from you, ask students to label each drawing. By a process of elimination, they should be able to identify most of the pictures. The answers are provided below.

1. water strider
2. dragonfly nymph breathing
3. dragonfly nymph expelling water to move
4. dragonfly nymph catching prey
5. caddisfly
6. diving beetle
7. damselflies mating
8. water scorpion
9. male giant water bug

Review the adaptations of these wetland insects by asking individual students to choose one of the drawings and describe the adaptation that insect has made.

EVALUATION Ask students to write a paragraph on one of the following topics. This assignment is especially appropriate if you have introduced comparison as a writing device. Encourage students to come up with other topics in which they compare the adaptation of a wetland insect to another, quite different application of the same principle.

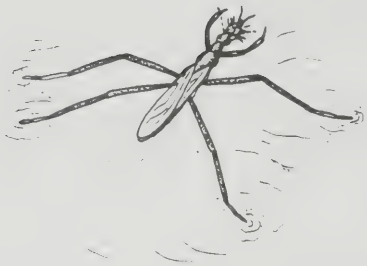
1. Compare the locomotion of the dragonfly nymph to the forward thrust of a jet plane.

2. If you blow up a balloon and then release it into the air, the balloon takes off. How is the movement of the balloon like the underwater locomotion of the dragonfly nymph?

3. Why is a canoe paddle or an oar shaped the way it is? How does this relate to the hairy rear legs of the diving beetle?

4. Compare the apparatus of a deep sea diver to the breathing adaptations of the water scorpion and the diving beetle.

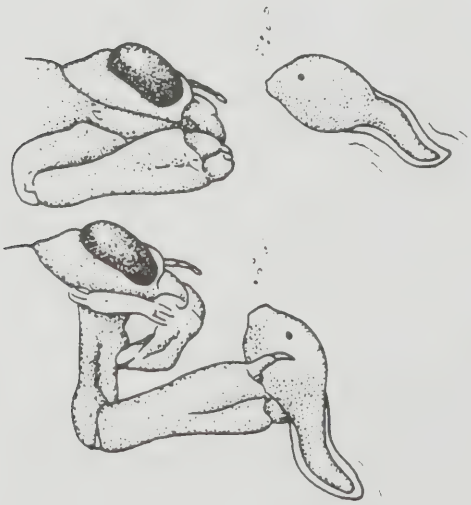
Minimarvel Insect Drawings



1. _____

2. _____

3. _____



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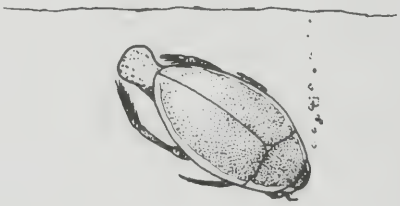

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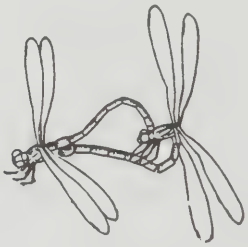

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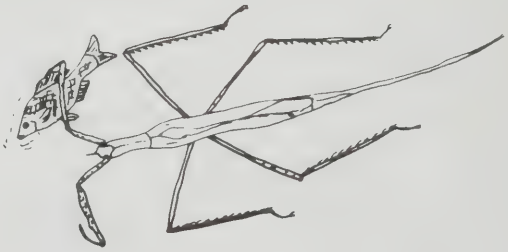

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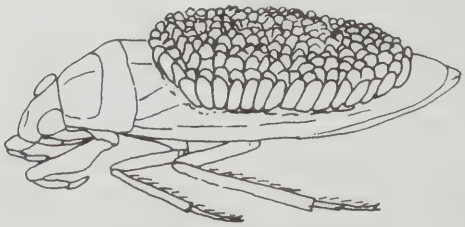


9. _____

Activity Six: More about Marsh Minimarvels

OBJECTIVE to learn some of the unique adaptations organisms have for living in aquatic environments

SKILLS observation, analysis, comparison

VOCABULARY animalcule, bryozoans, cilia (cilium), crustacean, flagellum (flagella), hemoglobin, hydrophytes, metabolism, photosynthesis, phytoplankton, predaceous, stoma (stomata; also stomate and stomates), surface tension

MATERIALS paper and pencils and copies of **The Water's Surface: A Ceiling for Some, a Floor for Others** (text and pictures), **Coping with Life Underwater** (text and pictures), and **The Best of Both Worlds** (text and pictures). Prior to class, mount one copy of each of the three picture sheets on cardboard and cut out the drawings as a set of cards. Place the cards in a box or sack.

COMMENTS This activity extends the previous activity and introduces other interesting adaptations of wetland plants and animals that take place on a very small scale. Because these are difficult to observe, they often go unnoticed by all but the most observant.

PROCEDURE 1. Distribute copies of the worksheet texts and their accompanying pictures for students to complete in class or as a homework assignment.

2. After the worksheets have been completed, appoint a student to act as quiz master and give that student the box of mounted pictures. The quiz master chooses a classmate to pick a card at random from the box. The student names the plant or animal shown on the card and describes its aquatic adaptation. As each organism is identified and its adaptation described, students correct their own worksheets. Answer questions and clear up misconceptions. You may wish to collect the worksheets to assess how students have done.

Typical but less well known wetland invertebrates include (from left to right) the nearly microscopic hydra, a relative of the jellyfish; a copepod, related to crayfish and lobsters; and leeches, which are a type of worm. The hydra and copepod are pictured much larger than life size.

EVALUATION Ask each student to write two riddles based on the information given in the worksheets and to copy each riddle on two slips of paper. Only one should include the answer to the riddle. Riddles may be written as statements or questions. If you wish, organisms introduced in the preceding activity can also be included in these riddles. Several examples are given below.

I have built-in bifocals. (whirligig)

Snorkelers learned a trick from me. (water scorpion)

Roots have I but rooted I am not. (duckweed)

A primary producer is what I am. Give me sunlight, oxygen, water—and stand back! (*Euglena* or phytoplankton or algae)

Collect the riddles, set aside the set with answers, and place the others in a box or sack.

Divide students into two or more teams and ask them to come up with a wetlands name for each team: Water Rats, Scorpions, and so on. Appoint two judges and give them the set of riddles with the answers. Teams take turns picking a riddle from the box. If the student who drew the riddle fails to answer it correctly, he calls on a volunteer from the opposite team. If that student also gives an incorrect answer, the first team gets a second chance to answer the riddle. Alternate until one team answers correctly. Judges are responsible for devising a simple system of keeping score, for ensuring that the rules are followed, for deciding if a riddle should be declared invalid, and for determining when an answer is correct. Continue until all riddles have been attempted.

Base your evaluation on the quality of the riddles as well as the responses.

The Water's Surface: A Ceiling for Some, a Floor for Others (text)

The surface of a quiet marsh or pond presents no barrier to a raccoon searching for crayfish or a heron attempting to spear an elusive tadpole. To small creatures, however, the water's surface presents a firm but flexible surface, and many plants and animals are well adapted for living at or near this surface. Surface tension results because water molecules are more strongly attracted to each other than to the air above. The surface of the water, therefore, is held in place from each side and from below; the result is a dense surface film of water molecules. Each of the plants and animals described here is adapted in some way for living at or near the water's surface.

1. The American featherfoil is an aquatic, flowering herb in the primrose family (loosestrifes and shooting stars, among others). Featherfoil floats on the surface of quiet waters by means of a spongy, inflated stem. Its feathery leaves are partially submerged or float on or near the water's surface. Small blue flowers occur in constrictions (axils) along the stem. Although the American featherfoil occurs mostly in the southern United States, it ranges north into the Midwest.

2. Fishing spiders occur along the shores of many wetlands and move about on the water's surface with considerable agility. They feed primarily on animals that have fallen into the water and become trapped in the surface film. Even though these spiders do not spin silken webs, the surface film of the water functions as a web.

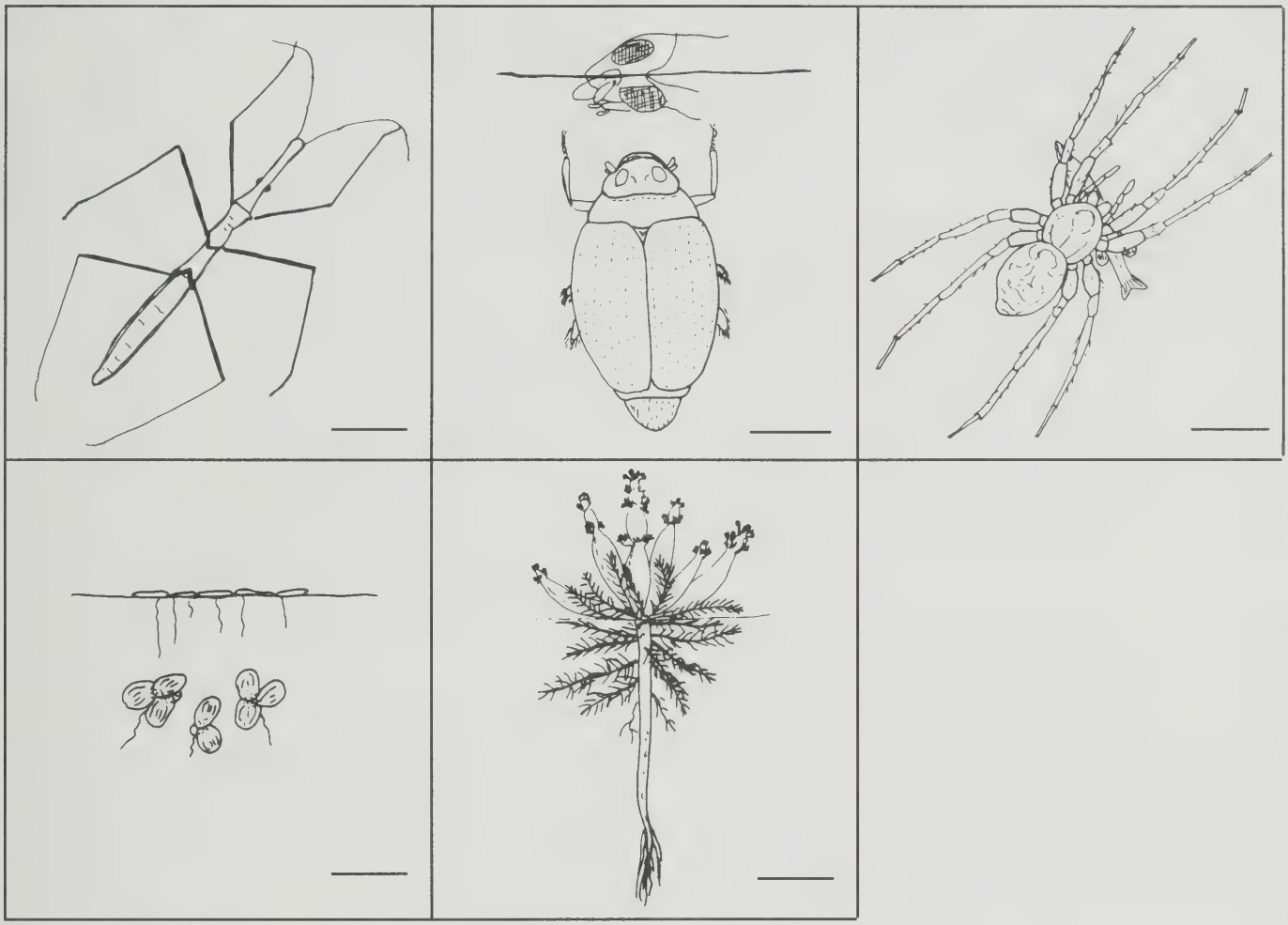
3. Marsh treaders, also called water measurers, are slender, sticklike predators or scavengers that live in vegetation found around the edges of ponds and marshes. Unlike their fast cousins the water striders, marsh treaders can walk very slowly on the water's surface. As a result, they seem to hunt in slow motion.

4. Duckweeds are small flowering plants that live on the surface. Tiny rootlets less than half an inch long dangle from the undersides of these plants. Duckweeds reproduce rapidly and can cover the surface of a wetland within a few weeks.

5. Gyrating, spinning whirligig beetles are familiar inhabitants of most quiet waters in the Midwest. Adults are specially adapted for living on the surface film. Their eyes are divided into upper and lower halves; the upper portion sees the world above the water while the lower portion keeps tabs on what's happening below the surface! Whirligigs often congregate in large schools and catch small prey or feed on dead organisms. Because only the upper half of the beetle is water repellent, it swims half above and half below the surface.

The Water's Surface: A Ceiling for Some, a Floor for Others (pictures)

Directions: Write the number of the description with the picture of the plant or animal it describes.



Coping with Life Underwater (text)

For most small animals, the surface film is a barrier between two entirely different worlds. Although some species regularly pass back and forth between the air and the water, others spend their entire lives submerged. Even in the deepest parts of the marsh, life abounds. Each of the plants and animals described here is adapted in some way to living under the water's surface.

1. Waterfleas are abundant members of most wetland communities. These small crustaceans, about the size of a pinhead, swim intermittently. Like their relatives—shrimp, crayfish, and lobsters—waterfleas have two pairs of antennae. Although we usually think of antennae as sensory apparatus, the waterflea uses its second pair, along with its legs, for swimming in jerky, characteristically flealike motions. Waterfleas are very important in the diet of many fishes and predaceous insects.

2. Bryozoans, also called moss animalcules, are tiny animals that form large colonies, usually attached to a submerged log or rock. To the casual observer, these colonies may resemble a mat of moss. Individual bryozoans are minute, and many thousands, usually encased in a mass of jelly, are required to make up a colony. Each colony member uses hairlike cilia around its mouth to bring in the microscopic plants and animals upon which it feeds.

3. Even deep in the water where the supply of oxygen is low, certain animals thrive. Along the bottom of a marsh or pond many kinds of worms feed on the rich, decayed remains of plants and animals. *Tubifex* worms are very common and sway by the thousands on the bottoms of ponds and marshes. Their movement causes the water to move and bring in food particles on which the worms feed.

4. Caddisfly larvae build houses of sand, rock, and sticks, and some also construct a fishing net. Unlike the airborne adults, the larvae live on the marsh bottom, where they feed on small food particles, scavenge dead organisms, or prey on other animals. One group of caddisfly larvae constructs silken nets that trap food particles, which the larvae then remove and eat. Another group uses silk from the abdomen to glue objects together to make cases in which the larvae live. Caddisfly larvae use various materials to construct cases that serve many functions, including protection, camouflage, and respiration.

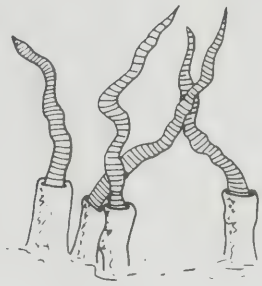
5. The tiny plants (mostly algae) in the water of a marsh can be incredibly abundant. They make up the phytoplankton. These chlorophyll-containing plants produce food for larger aquatic animals by converting sunlight, carbon dioxide, and water into food by a process called photosynthesis. An abundance of single-celled *Euglena* (whether it is a plant or animal is yet to be determined) may turn the water green. This organism swims through the water by means of a whiplike flagellum.

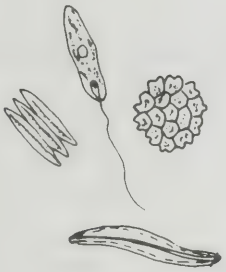
6. Marshes are inhabited by carnivorous plants that are different from those found in bogs but just as deadly. The submerged bladderwort has tiny sacs on its leaves, each with a bristlelike trigger. When the trigger is tripped by a very small organism, the sac opens and sucks in the hapless victim.

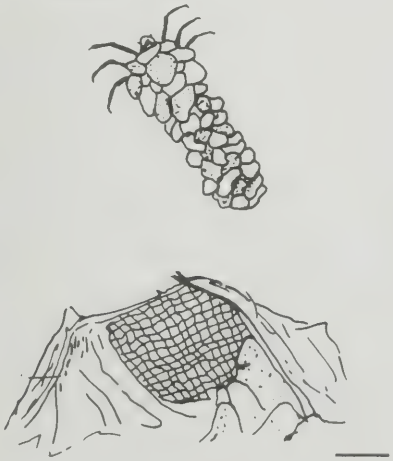
7. Mussels have an unusual beginning to their lives. The parent mussel releases its young, called glochidia, into the water, where they must attach themselves to suitable host fish. Some species attach to the gills, others to fins. The young mussel has a hook that it uses to make this attachment, and that is why it is called a glochidium, from the Greek word *glokhis*, meaning the barb of an arrow. The young mussel lives in the fish's tissue until it transforms into an adult. It then leaves the fish, drops to the bottom, and begins the familiar life of mussels as filter feeders.

Coping with Life Underwater (pictures)

Directions: Write the number of the description with the picture of the plant or animal it describes.







The Best of Both Worlds (text)

Whereas many animals, including fish and mussels, are superbly adapted for living entirely in water, others are adapted for living both on land and in the water. Turtles, frogs, toads, snakes, and particularly birds all breathe air but are also adapted for underwater swimming and diving. Plants that live in marshes (hydrophytes) also must cope with a wide range of conditions, from deep standing water to the bone-dry conditions of midsummer, and they do so in a number of fascinating ways.

1. Air-filled spaces within spatterdock leaves make these leaves float on the water's surface. No matter how long and heavy the stems become, the leaves stay afloat. Although most plants have openings (stomates) on the underside of their leaves to allow carbon dioxide and oxygen to pass in and out, the spatterdock has its stomates on the upper side of its leaves, away from the water.

2. Grebes are diving ducks that have extensions of their lungs (air sacs) throughout their bodies; thus, they float readily. Before diving, they must eliminate much of the air within their bodies if they are to submerge. How then do these birds get enough oxygen for relatively long dives? Their blood is richer in the chemical that carries oxygen (hemoglobin) than the blood of other birds, and their heartbeat and other body functions slow down to conserve oxygen while diving.

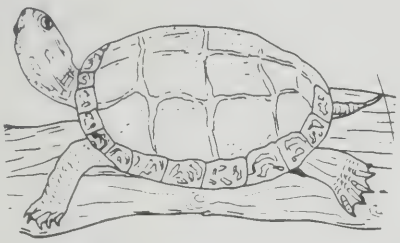
3. The painted turtle spends a good portion of its life in or near wetlands. Many of the daylight hours are spent basking in the sun, usually on a convenient log. The heat from the sun increases the turtle's body processes (metabolism), helps prevent algae from growing on its shell, and discourages external parasites, such as leeches. With the slightest disturbance, however, the turtle plunges into the water, where its large webbed feet make efficient paddles.

4. Two entirely different kinds of leaves help the water marigold survive as an emergent plant. The leaves above the water are typical terrestrial plant leaves that exchange gases through stomates. The underwater leaves are very lacy, with large surface areas that absorb and give off oxygen and carbon dioxide directly into the water through their cell walls.

5. The toad, like many amphibians, spends most of its adult life on land. It is, however, tied to the water for reproduction, and the spring marsh resounds with a symphony of the piercing trills of courting toads. After mating, the female lays a double string of eggs, 3 to 4 feet long and containing many thousands of eggs. Most hatch within a few weeks into tadpoles, but few will survive the numerous predators of the marsh to become adults.

The Best of Both Worlds (pictures)

Directions: Write the number of the description with the picture of the plant or animal it describes.



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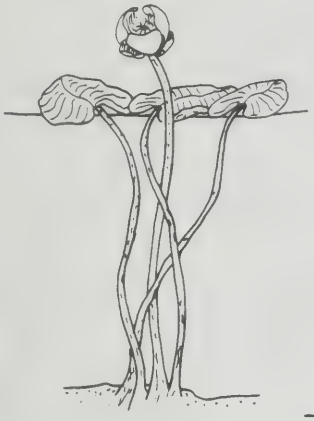

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Activity Seven: Get Your Hands and Feet Wet

OBJECTIVE to sample the organisms in a wetland habitat, to take its physical measurements, and to establish a database on that habitat and its occupants

SKILLS construction of sampling equipment, sampling techniques, handling of organisms, identification of organisms, data collection, data management

VOCABULARY acidity, alkalinity, ecological benchmarking, replication, sampling

MATERIALS multiple copies of **Data Sheet: Wetland Organisms, Data Sheet: Water Temperature and pH, Wetland Animal Identification,** and **Wetland Plant Identification**; field guides for the various organisms likely to be found (suggestions are given on page 68)

The equipment needed for wetland sampling need not be sophisticated or expensive. Although most of the items described in the procedure are available commercially from biological supply houses, students should be encouraged to construct their own equipment. Suggestions for student-made equipment are given in Appendix B. In some cases, alternative equipment is suggested that may be available from local merchants. You will need white enamel or plastic pans, folding pocket magnifying lenses, forceps (tweezers), large and small eyedroppers (a turkey baster works well for the large eyedropper), plant rake (a small garden rake will do), sorting screens (fine and coarse mesh), aquatic net, collecting jars, simple dredge for bottom sampling, box with a glass bottom, graph paper for mapmaking, and boots (for the students measuring water depths and temperatures).

COMMENTS Now that students have studied wetlands in the classroom, they are ready to experience a wetland habitat firsthand, exploring its physical components and discovering its many organisms. If possible, choose a single wetland area near your school and learn everything you can about it. Visit the area over several seasons with different classes, and before long you will have developed a good understanding of the natural history of that particular habitat. Have students record their observations on the chosen site and maintain this information as a permanent "wetland database." Your database can be kept in file folders or computerized. Such a file of information is extremely valuable, particularly because it allows students to compare current data with information from past years. Include a natural history collection with examples of the different types of organisms students have found. Changes in the physical and biological makeup of the habitat, as well as seasonal changes, can be documented if identical measurements are taken from year to year. Organisms collected in subsequent years can also be compared with the class reference collection to aid in identification and to note differences in the fauna and flora from year to year. Such information, obtained in a uniform way over many years, is called *ecological benchmarking* and is a powerful tool for monitoring habitat change. Also remember that the area should be disturbed as little as possible by each class so that it will remain as natural as possible.

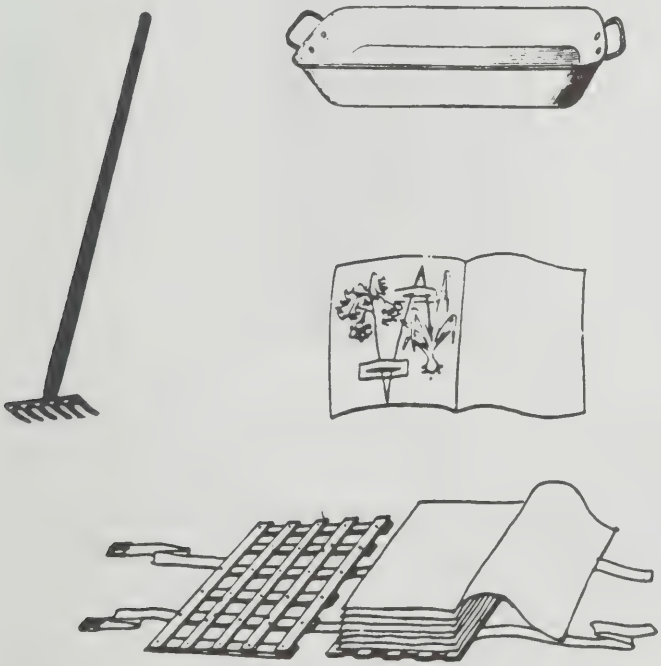
Choosing a site for long-term study by your classes may be the most difficult part of this exercise. The habitat or area to be studied should have the following characteristics:

1. some standing water for most of the year and water less than 6 feet deep during the wettest part of the year
2. emergent vegetation along the shoreline (cattails, arrowheads, etc.)
3. accessibility
4. permanence (avoid sites likely to be destroyed within a few years)

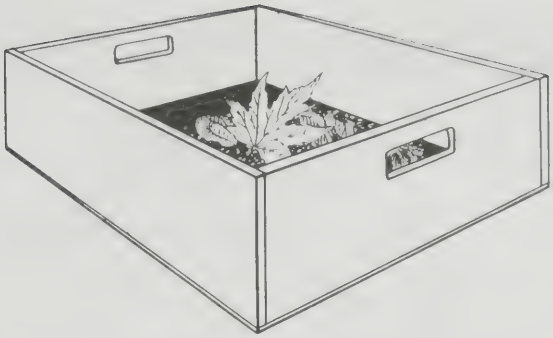
Ponds can be used for this exercise if they meet the above criteria. The pond must be shallow, however, and have vegetation along its shoreline; otherwise the organisms found may not be representative of a wetland. Other wetlands that may be used include the shallow end of a large lake, preferably where a meandering stream enters it, or a true cattail marsh (although access to the shoreline may prove difficult here). Even a roadside ditch will serve if it has been in existence for several years, holds water for most of the year, and has typical wetland vegetation.

PROCEDURE 1. Students should have completed at least some of the preceding six activities before they visit a wetland site. Before leaving the classroom, divide students into working groups of four or five and assign each group one of the data-collecting tasks described below. Assign one student to serve as photographer or assume this role yourself. Distribute copies of the data and identification sheets listed on the previous page.

2. Each group conducts its assigned task at the site and records the data on the appropriate information sheets. Explain that the process of replication is extremely important in any scientific endeavor. The group taking temperature measurements, for example, cannot rely on a single measurement from a given depth but must repeat the process several times to obtain an average reading for that depth. Students sampling the bottom with a dredge must repeat the process several times in the general area, making sure they do not resample an area just sampled and therefore already disturbed. A separate data sheet for organisms should be used for each replication. After students return to the classroom, they can combine, summarize, and average data from the various replications. Replication applies to all activities listed below except photography. An alternative approach is to have each group of students complete only one replication of a task and then change activities so that all groups have an opportunity to perform every task.

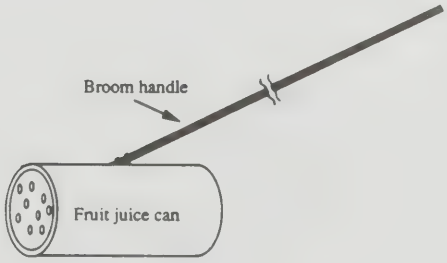


3. A small garden rake can be used to collect samples of emergent and submerged aquatic vegetation. Samples should be placed in enamel or plastic pans, usually in water, for further examination. Plants for the reference collection should be pressed (in a plant press, if possible); labeled with name, date, location, and collector; and stored as dried specimens.

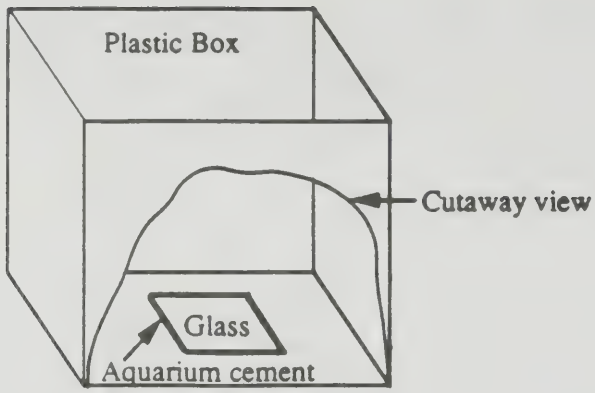


4. Sorting screens are useful for separating bottom-dwelling animals from mud and debris. Two sizes should be constructed, one from hardware cloth (relatively large holes) for separating larger objects from the sample of bottom debris and one from regular window screen for capturing very small animals. After collecting the bottom sample with a dredge (see item 6 below), a student holds the screen with the larger mesh on top of the other screen, pours the sample onto the larger screen, and rinses the sample with water to wash mud, silt, and smaller particles onto the lower screen. The top screen is then examined for organisms, which should be carefully collected. Examine the lower screen to collect smaller organisms. Both screen samples may be washed into enamel pans for further study. Hard-bodied insects may be pinned, labeled, and stored as a typical insect collection; soft-bodied animals and submerged plants should be stored in 70% ethyl alcohol. Labels should be written in pencil and dropped in the jar with the specimens.

5. The most useful sampling device is a long-handled dip net. The rim of the net must be sturdy enough to withstand being swept through vegetation tangles and other debris in the water. Nets may be purchased from supply houses or made by purchasing a fishing dip net, removing the rather large mesh bag, and replacing it with a hand-sewn bag of sturdy muslin. If the net is to be dragged along the bottom, one side should be flat so that a larger area can be sampled (see Appendix B for construction). Samples may be dumped into an enamel pan or washed through the sorting screens before dumping them into the pan.



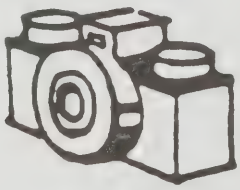
6. A dredge may be made by bolting a fruit juice can to a broom handle or other long pole. Flatten one side of the can to increase its contact with the pond bottom. Drill several small holes in the bottom of the can so that excess water flows out during sampling. Process the sample as noted above by screening and placing in an enamel pan.



7. A simple device will enable students to see what's happening underwater. Cut a square hole in the bottom of a plastic tub. Use silicone aquarium cement to glue a piece of glass over the hole so that the tub remains watertight. Paint the inside of the box black to reduce glare. When the box is placed just under the surface of the water, surface glare is eliminated and students can observe the activities of organisms underwater. Appoint one student to report observations to another student who serves as note-taker; include these observations with the other data collected during the field trip.

8. Tie a piece of twine to an ordinary thermometer. Use a waterproof marker to indicate one-inch intervals on the string. When the thermometer is lowered into the water, temperatures may be measured at any depth. Remind students to account for the distance between the bulb of the thermometer and the beginning of the string. After the thermometer has been lowered to the desired depth, it should be left there for a few minutes to allow the temperature to register. The thermometer should then be pulled up quickly and the temperature recorded.

9. A simple kit for testing water pH (acidity or alkalinity of the water measured as the concentration of hydrogen ions) may be purchased from a pet store. Changes in the pH of wetlands can have drastic effects on the plants and animals that live there. Sources of hydrogen ions include soil and atmosphere (rain falling through polluted air yields acid rain).



10. Use a camera to record seasonal changes around your chosen site. Place permanent stakes around the margin of the wetland and take pictures, facing in the same direction, each time you visit the area. One or two pictures from each station is sufficient. You will soon have a record of the above-water changes that occur as the seasons change.

11. Students who are sampling the plants and animals in the wetland will be able to identify only a portion of the organisms they collect. Field guides and the plant and animal identification sheets will help with identification. All organisms collected should be identified at the site and returned to the water, with the exception of those that will make up the class reference collection. In some instances, students may wish to keep certain plants or animals alive in a bucket of water to be identified the next day in class. Remember that each specimen that is placed in alcohol should be accompanied by a label written in pencil and listing the collection site, date, time, collector, method of collection, and identity of specimen (if known).

12. A student or group of students may be designated as mapmakers. With graph paper calibrated to X number of feet per unit, students should map the study area as accurately as possible. Later, a larger version may be produced in the classroom, and students can add information to the map from their sampling data. Include information on water depth and pH, distribution of emergent and submerged vegetation, and dredging sites. These maps should be saved from year to year. They will prove to be invaluable in documenting changes in the area over time and will become part of the permanent database for your wetland.

13. The information students have recorded on the data sheets can serve as a permanent database for the site. In addition, you may wish to set up a simple computerized database into which students enter the information collected. The reference collection should become a permanent part of the classroom and can be used by students to identify organisms collected on subsequent trips to the site.

EVALUATION The information collected at the site and its incorporation into the ongoing database serve to evaluate the success of this activity.

Data Sheet: Wetland Organisms

Sample number or replication _____

Sampling method (circle one): plant rake dredge aquatic net

Location of sample (circle one): shoreline bottom surface of water

Record on the lines below each kind of organism found and the number of individuals found. Identify organisms to the lowest level possible. Be as specific as you can. For some—worm, mussel, or insect, for example—you may be able to supply only general terms; for others, you may be able to identify the species (for instance, cattail, arrowhead, whirligig beetle).

Kind of Organism	Number of Individuals in Sample

Data Sheet: Water Temperature and pH

Temperature. Choose three water depths and complete three replications at each depth.

Sample	Replication	Depth	Temperature	Average temperature
A	1	_____	_____	
	2		_____	
	3		_____	
				Sample A _____
B	1	_____	_____	
	2		_____	
	3		_____	
				Sample B _____
C	1	_____	_____	
	2		_____	
	3		_____	
				Sample C _____

pH (acidity or alkalinity). Choose three sites (shoreline, shallow water, deepest water) and complete three replications at each site.

Sample	Replication	pH	Average pH
Shoreline	1	_____	
	2	_____	
	3	_____	
			Shoreline _____
Shallow water	1	_____	
	2	_____	
	3	_____	
			Shallow water _____
Deepest water	1	_____	
	2	_____	
	3	_____	
			Deepest water _____

What is the average temperature of the entire wetland?_____

What is the average pH of the entire wetland?_____

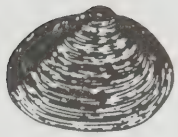
Which data are most meaningful—averages by depth and location or averages for the entire wetland? Why?

Wetland Animal Identification

Damselfly nymph

Caddisfly larva

Crayfish



Clam/mussel

Dragonfly nymph

Crane fly larva

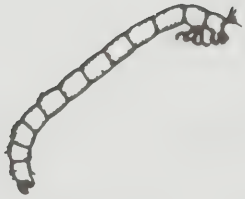
Mayfly nymph

Sowbug

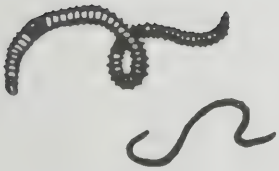
Scud

Right-handed/other snails

Stonefly nymph

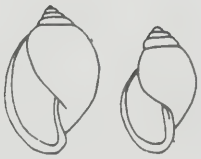


Midge larva



Aquatic worms

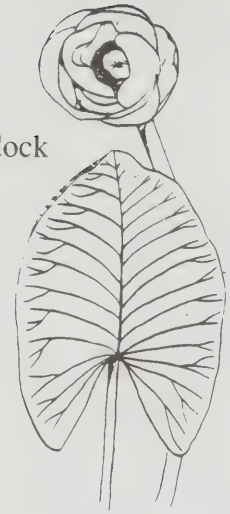
Leech



Pouch/left-handed snails

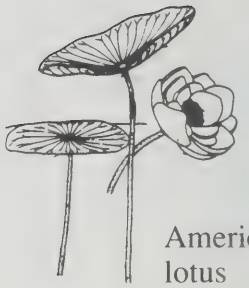
Blood worm
midge larva

Water horsetail

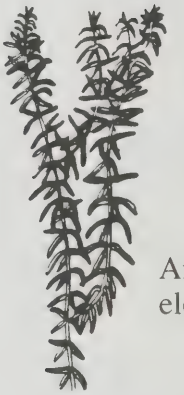


Spatterdock

White water lily



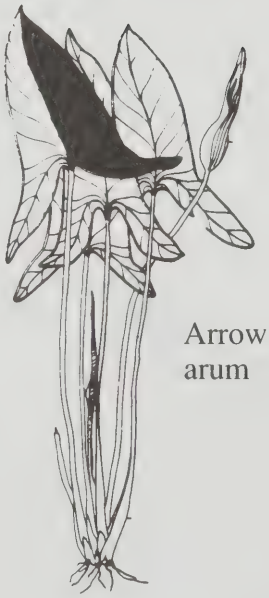
American lotus



American elodea

Water smartweed

Common arrowhead



Arrow arum

Cattail

Activity Eight: Wild and Wet

OBJECTIVE to review factors that affect the ecology of a wetland habitat

SKILLS social interaction, concept reinforcement, value judgments

MATERIALS for each group of four students:

- a copy of **Rules of the Game**
- a game board (folded insert). If time permits, game boards may be colored and mounted on cardboard. Duplicate game boards can be made by copying the board in fourths and taping together. **Extra copies of the game board can also be obtained from the Illinois Natural History Survey**.
- a set of fact cards. Mount a copy of **Wetland Facts** on cardboard and cut out a set of cards, one statement to a card.
- a die and tokens. Students may construct tokens following those given on the handout **Templates for Tokens** or use buttons, pennies, or cardboard shapes.

COMMENTS This game acquaints students with the biological complexities of a wetland habitat and reviews factors that destroy or sustain midwestern wetlands and their associated landscapes. Students should enjoy the game, but they should also perceive the biological and social relevance of the information presented.

PROCEDURE 1. Divide the class into groups of four students. Distribute the materials so that each group has a game board, a copy of the rules, a die, tokens, and a set of fact cards.

2. Ask students to read the rules before beginning play, or explain the rules to the class as a whole. The latter may be the preferred strategy because you can emphasize the concepts that students should think about and discuss during the game.

3. Monitor the play because lively discussions are likely to develop. Assist any group that has difficulty understanding the information presented in **Wetland Facts** or reaching fair and reasonable decisions. Various labels for the same statement are possible. A given statement, for example, may be judged positive by one group and neutral by another. One label is not necessarily more correct than the other, but the justification for the choice should be plausible.

EVALUATION Each student selects one statement from **Wetland Facts** and writes a paragraph explaining why that statement is positive (beneficial) or negative (detrimental) in regard to wetlands and their associated landscapes. Check the choices before students begin writing to ensure that no one has selected a neutral statement unless he or she has an idea for a valid explanation.

Rules of the Game

1. One player shuffles the fact cards and places them face down in the center of the playing board.

2. Each player chooses a token and places it on **Start**.

3. Each player in turn rolls the die; the player with the highest number begins the game by rolling the die again and moving his or her token forward the appropriate number of spaces.

4. If the token lands on an unshaded square, the turn passes to the player on the left. If the token lands on a shaded square, the player draws a fact card from the top of the pack and reads aloud the statement on it. The other three players then decide if the statement is positive (beneficial), negative (destructive), or simply neutral with regard to wetlands and their associated landscapes. The player who landed on the square may express an opinion, but the ultimate judges are the other three players. If the statement is considered negative, the player moves back one space. If the statement is considered positive, the player moves forward one square. If the statement is considered neutral, no change is made. After the player has moved to the appropriate square, his or her turn is over and the die passes to the player on the left.

5. If a player's token lands on an occupied square, the player moves it back to the nearest unoccupied square.

6. Play proceeds in a clockwise direction and continues until each player reaches **Finish**. Finishing first may in itself be enough reward, but you can also grant the winner the power to be sole judge of the wetland facts for the remainder of the game. The other three players, of course, continue to express their points of view.

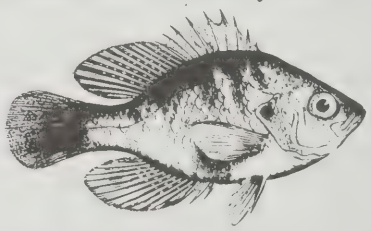
Sixty acres of wetlands are destroyed each hour in the United States.	During dry weather, mudflats are exposed, and moist-soil plants grow and produce seeds that are eaten by waterfowl.
The water table in a marsh is permanently lowered by the drainage of adjacent farmland.	During late summer when the water level drops, marsh soils are exposed to oxygen, thereby speeding the process of plant decay and the recycling of nutrients.
When water levels drop, fish and other animals are concentrated in small pools. Wetland birds such as herons, egrets, and eagles have a feast.	A family of beavers dams a small stream to create a large, shallow, wet area. Soon cattails, bulrushes, and arrowhead plants colonize the site.

The leaves of floating plants, such as water lilies, provide a home for many small animals on their upper and lower surfaces.

Frogs, toads, and salamanders find wetlands ideal feeding and breeding grounds each spring and early summer.

Along the wetland margin, abundant cattails, rushes, and sedges provide an ideal home for the endangered rice rat.

Fishes that inhabit marshes must be able to tolerate muddy water and relatively warm temperatures.



Migrating birds use wetlands on a seasonal basis to rest, feed, and raise their young.

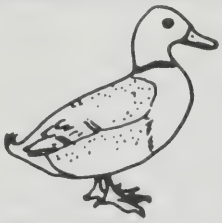
Many kinds of invertebrates—including mollusks, sponges, flatworms, crustacea, and insects—are important parts of food chains and transfer energy to other organisms.

The different water depths in a marsh allow both dabbling (mallard) and diving (canvasback) ducks to forage for food.

The presence of mussels and snails indicates that water is relatively clean and free of pollution.

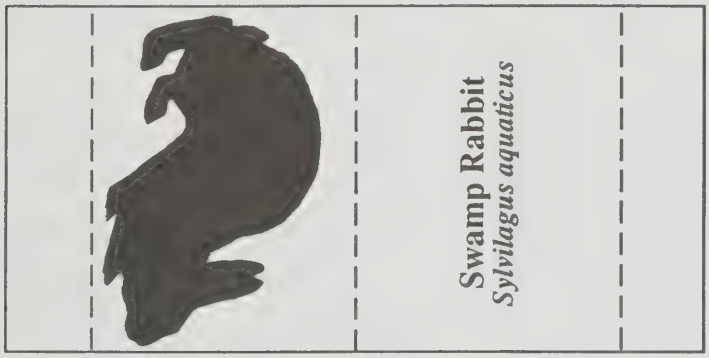
More kinds of plants live in the moist soil around wetland edges than live in the open water.	Cattails and bulrushes take up a large percentage of polluting nitrates that are washed off from nearby farm fields and convert these chemicals to plant tissue.
A large quantity of living things (biomass) is produced in a wetland; thus, wetlands are said to be highly productive.	Soil eroded from nearby fields (sediment) is trapped by wetland plants and settles to the bottom before it can enter a river.
The soils and water in a bog are very acidic and allow only a few species of plants to grow there.	A wetland next to a large river is leveed, drained, and planted with corn. During the rainy season, water that originally remained trapped in the wetland now flows downstream and causes flooding.
Wetlands provide habitat for an incredible number of plants and animals.	Peaty and mucky wetland soils attract polluting chemicals and allow them to be broken down by microorganisms.

Extra nitrogen (nitrates) from farm fields allows a single species of plant, cattails, to outcompete its neighbors, thereby reducing the diversity of the marsh.	One-third of all threatened and endangered plants and animals in the United States rely on wetlands for their homes.
Wetlands act as sponges and store water from wetter times. During a drought, this water is slowly released into nearby streams.	Wetlands are beautiful.
For wetlands to serve their biological functions, they must not be leveed, drained, channelized and straightened, or stripped of their native vegetation.	Of the original 221 million acres of wetlands in the United States, only 103 million acres remain.
More plant material is produced in a marsh than in a cornfield. Wetland plants can produce 25,000 pounds of dry plant matter per acre; an acre of corn yields about 12,500 pounds.	By 1920, 750,000 acres of river bottomland in Illinois had been leveed and drained.

Wildlife use wetlands as corridors through which they move in search of food and shelter. 	Wetlands reduce flood peaks by storing water.
In the span of one generation, over half of Iowa's wetlands have been lost.	Wetlands have a profound ability to improve water quality. They help to keep water supplies clean by trapping sediment and filtering out contaminants.
Prairie wetlands are the most productive of all temperate ecosystems. Their lush growth is used by wildlife for food, cover, and breeding.	Wetlands reduce the turbidity of water. As sediment-laden water enters a wetland, it loses velocity, and the suspended solids settle to the bottom.
Ten states in the United States have lost more than 70% of their wetlands.	Wetland vegetation has a filtering effect. Solids are knocked out of the water as they attach to the stems and roots of aquatic plants.

Wetland plants improve water chemistry. Nitrogen, phosphorous, and carbon provide the basic elements for the growth of plant cells. As these three elements are removed from water and put into plant production, the water becomes cleaner.	Drained and tiled wetlands have made some of the richest farmland in the Midwest.
More than 117 million acres of wetlands have been lost in the lower 48 states since colonial times—over half the estimated original total wetland acreage.	In harsh winters with heavy snow, the dense tangle of marsh vegetation provides cover for pheasants—sometimes the only cover they can find.
In Iowa and elsewhere, nitrates are a serious source of groundwater contamination and a threat to the quality of drinking water. Because nitrates are very soluble, they leach quickly through the soil into shallow aquifers. If nitrates enter a wetland, however, they experience a chemical transformation. The microbes present in wetland sediments convert the potentially harmful nitrates into nitrogen gas, which is harmless.	Some people maintain that the highest value to be placed on wetlands is their potential development as real estate and crop-producing acreage.
A study conducted in Eagle Lake Marsh, Iowa, found that 86% of the nitrate level of the lake had been removed by the time the water made its way to the outlet of the marsh.	Some people maintain that the highest value to be placed on wetlands is their ability to improve the quality of water and to provide habitat for a remarkable diversity of plants and wildlife.

Wood Duck
Aix sponsa



Swamp Rabbit
Sylvilagus aquaticus

Pumpkinseed
Lepomis gibbosus

Green Frog
Rana clamitans

Activity Nine: Discovering Beauty in the Muck and Mud

OBJECTIVE to perceive the value of wetlands in aesthetic terms

SKILLS aesthetic perception, personal expression, communication

MATERIALS paper and pencils

PROCEDURE 1. List with the class as many words descriptive of wetlands as students can come up with in a stipulated time, perhaps 5 minutes. Encourage rapid responses, building on the associative values of words, not necessarily logical connections. Your list might begin something like this: water, wet, damp, dark, dank, mud, muck, slime, green, turtle, fish, gill, fin, swamp, bog, bird, heron, bug, predator, prey, food web, duck, silt, filter, erosion, sediment, mussels. Supply a word or two yourself when ideas wane.

2. When the time limit has been reached or no additions are forthcoming, ask students to use words from the list along with others of their own to create a poem or descriptive passage expressing their personal feeling about an aspect of wetlands. Poems need not rhyme, and students may elect to write from the point of view of a wetland plant or animal.

3. Several examples are given below. Share them with the class only if you think they will help students get started on the assignment.

Why Wet?

Water
Eases
Troubled lands
Winding
Effortlessly
Through scrub and tree
Weaving each to every.
Wet is why.

Bugfood

Bugs are to swat as we all do,
But stop to take a wider view.
From bug to fish to folks like me,
Without those bugs where would we be?
Break the food chain at your risk—
Even the bug is sorely missed.

The Heron

Sharp in silhouette against the sunset stands the heron.
Sharp eyed, sharp beaked, snake necked.

Wetland Warning

Wetlands are the why,
Wetlands are the wherefore.
If the wetlands go dry,
Run from the therefore!

Night Lilies

The silver water lilies float silently on the black water
anchored secretly in the deeper darkness below.

4. The completed poems may be illustrated and compiled into a booklet or arranged as a bulletin board display. In any event, authors should be encouraged to share their productions with the class.

Whooping cranes were forced to the brink of extinction by hunting and by destruction of their wetland habitat.

Wild iris are found in many wetlands, including marshes, swamps, and fens.

EVALUATION Student writing should serve as its own evaluation, but you may wish to expand this activity with other reading and writing assignments. Several ideas are suggested below.

1. The last stanza of Gerard Manley Hopkins' poem "Inversnaid" is particularly appropriate. The complete poem can be found in anthologies of English literature or in the works of Hopkins.

> What would the world be, once bereft
> Of wet and of wildness? Let them be left,
> O let them be left, wildness and wet;
> Long live the weeds and the wilderness yet.

Students might try writing a brief response to Hopkins' question, "What would the world be, once bereft of wet and of wildness?" The poem also lends itself to illustration.

2. Theodore Roethke spent his childhood in Saginaw, Michigan, where he absorbed a great deal of information working and playing in his father's huge greenhouse. That information was later put to use in many of his poems. In "Moss Gathering," he describes going out into the marshes to collect moss that was sometimes used to line cemetery baskets. He concludes,

> But something always went out of me when I dug loose those carpets
> Of green, or plunged to my elbows in the spongy yellowish moss of the marshes:
> And afterwards I always felt mean, jogging back over the logging road,
> As if I had broken the natural order of things in that swampland;
> Disturbed some rhythm, old and of vast importance,
> By pulling off flesh from the living planet;
> As if I had committed, against the whole scheme of life, a desecration.

Students might try their hands at explaining in prose or verse a desecration they have at one time or another committed against the natural order of things.

3. Many other poems celebrate wetland creatures, and your language arts text may contain several. Among those that your librarian can easily locate are these:

> "A Narrow Fellow in the Grass" by Emily Dickinson
> "The Fish" by Elizabeth Bishop
> "The Death of a Toad" by Richard Wilbur
> "Hurt Hawks" by Robinson Jeffers
> "To a Snail" by Marianne Moore

Because these poems require careful reading and some puzzling over words and metaphors, you might try assigning a poem to a small group of students who work out an interpretation together. Later they can choose a member of the group to read the poem to the class, another to summarize the group's interpretation of the poem, and a third to give a brief biographical note about the author.

4. Sarah Orne Jewett's story "A White Heron" offers possibilities for lively and thoughtful discussion. Because the story is short, six or seven pages, you might like to read it aloud to the class, or read the narrative passages yourself and assign the dialogue of the three characters to three student "actors." If possible, bring in a dramatic photograph of a white heron.

5. Thoreau, of course, is the source for many thought-provoking lines about the wild and the wet. One of the most famous is the one-page passage on the building of Billerica Dam, including "Poor shad! where is thy redress? When Nature gave thee instinct, gave she thee the heart to bear thy fate? Still wandering the sea in thy scaly armor to inquire humbly at the mouths of rivers if man has perchance left them free for thee to enter." And another: "Who hears the fishes when they cry?" (These passage are found in "Saturday" in *A Week on the Concord and Merrimack Rivers*.) Quotations from Thoreau can serve as keynotes for short papers or used as titles for posters.

6. This activity also provides an opportunity to view once again some or all of the 20 slides that accompany this publication. Several—for example, slides 3, 4, 9, 11, 19, or 20—can be used as the basis for a poem or descriptive paragraph.

Activity Ten: Picture Perfect

OBJECTIVE to recognize the diversity of wetland plants and animals and to appreciate their unique qualities and remarkable beauty

SKILLS library research, summarization, oral reporting, aesthetic appreciation

MATERIALS

• a copy of the wetlands poster for each student. This publication includes only a sample copy of the poster. **Classroom sets of 30 posters (on heavier paper stock) can be obtained for $3.50 from the Illinois Natural History Survey.**

• a copy of **Poster Word Key** and **Poster Picture Key** for each group of five or six students. Cut one **Poster Word Key** apart so that each plant or animal name is on a small slip of paper. Make duplicates of some names if your class has more than 31 students. Put these slips in a box or sack.

• colored pencils, water colors, felt-tipped pens

• file cards

• field guides to plants and animals such as the Peterson guides to freshwater fishes and birds

PROCEDURE 1. Divide the class into groups of five or six students. Give each group a wetlands poster. Do not distribute coloring materials at this time. Ask each group to list on a piece of paper the plants and animals on the poster. Then ask each group to categorize its list under the following seven headings: plants, birds, mammals, insects, fish, mollusks, and reptiles and amphibians.

2. Encourage students to take a second look by providing a hint: The poster shows 12 plants, 9 birds, 2 mammals, 2 insects, 2 fish, 1 mollusk, and 3 reptiles and amphibians. Allow a minute or two more for additional identifications.

3. Distribute a **Poster Word Key** to each group and ask students to use it to help identify plants and animals overlooked or unknown to them earlier. Allow a few minutes for students to revise their categorized lists.

4. When students are unable to make further identifications, distribute a **Poster Picture Key** to each group so that all plants and animals can be identified.

5. Disband groups and ask each student to select one of the plant or animal names from the box. The name drawn identifies that student's research subject. Depending on how your class is scheduled, you may wish to break the activity here and continue it on the following day. With older students, you may complete the activity as homework.

6. Each student must find several interesting facts about his or her research plant or animal. Specifically request that information about coloration be included. Findings may be presented orally in class, but the information should also be written on note cards for subsequent reference.

Suppose, for example, that a student draws the blackstripe topminnow. In the Peterson field guide to freshwater fishes, he or she will discover that topminnows have earned their name because they spend most of their time swimming at or near the surface of the water. The blackstripe topminnow has a wide blue-black stripe along its side and around its snout. It is olive-tan above with a silver-white spot on the top of its head and white to light yellow below. Because the male has crossbars on its stripe, we know that the fish pictured on the poster is a male. This species' favored habitat is quiet surface water, usually near the margins of creeks and small rivers, ponds, and lakes. A watercolor of the blackstripe and a map showing its distribution are also given in the guide.

7. Distribute a copy of the poster to each student along with the coloring materials. Share the research information in class. It will enhance the meaning of the poster and serve as a guide for students who elect to color their posters.

8. Use several of the posters as a classroom or hall display. One idea is to ask students to summarize their research findings on a file card. Use yarn to link each card to its corresponding picture on the poster. Avoid too many cards clustered around a single poster by designating one poster for birds only; color the nine birds and attach their research cards. Do the same for the 12 plants. Use a third poster for the remaining five categories: mammals, insects, reptiles and amphibians, mollusks, and fish. A fourth poster might show all plants and animals in color with no attached cards.

EVALUATION Collect the research cards and distribute them at random so a given plant or animal is not associated with the student who first reported on it. Ask each student in turn to read several of the salient facts from the research card he or she was given, being careful not to name the plant or animal. The student then calls on a classmate to identify the organism described. If the answer is incorrect, the student asks for help from volunteers. If no one makes a correct identification, the research reader provides more clues from the card until the plant or animal is identified.

Poster Word Key

Plants

1. Fragrant water lily
2. Marsh marigold
3. Wild iris
4. Yellow pond lily
5. Pickerel weed
6. Arrowhead
7. Swamp milkweed
8. Cardinal flower
9. Umbrella sedge
10. Cattail
11. Sedge
12. Duckweed

Mammals

13. Muskrat
14. Jumping mouse

Reptiles and Amphibians

15. Snapping turtle
16. Chorus frog
17. Bull frog

Birds

18. Black-crowned night heron
19. Red-winged blackbird
20. Yellow-headed blackbird
21. Sora
22. Pied-billed grebe
23. Blue-winged teal
24. Least bittern
25. Marsh wren
26. Black tern

Mollusks

27. Aquatic snail

Insects

28. Dragonfly
29. Diving beetle

Fish

30. Blackstripe topminnow
31. Pumpkinseed

Poster Picture Key

Activity Eleven: Who Decides the Future of Wetlands?

OBJECTIVE to evaluate alternative points of view regarding the preservation of wetlands

SKILLS evaluation, decision making, argumentation

PROCEDURE 1. Divide the class into groups of two or three students and assign each group one of the following roles. Substitute other roles of your own and incorporate suggestions from the class.

construction worker
unemployed person
fertilizer manufacturer
bank president
real estate agent
Audubon Society president
canoe club member
tile manufacturer
fishing enthusiast
drainage company owner
environmentalist
hunting club owner
farmer
newspaper editor
homemaker with two children
science teacher

2. Develop the following scenario in a way that is appropriate to the age level and experiences of your students. Feel free to delete information or to add details of your own.

We live in Riverdale, a midwestern city of about 150,000. Unemployment in Riverdale is higher than the state average; last month it reached a 10-year high of 13%.

Riverdale is located on a river, and extensive wetlands encompass both sides of the river about 5 miles outside the city limits. These wetlands are surrounded by rolling farmland.

Riverdale's mayor has called a town meeting to discuss a proposal to drain a major portion of these wetlands. A local construction firm has petitioned to drain the land so that it will meet the zoning requirements for a housing development. Three farmers are also interested in the proposal because the value of their land will increase if it is incorporated into the housing development. Several other farmers are also interested but for a different reason; they hope to add some of the drained acreage to their existing cropland.

In recent years there has been significant flooding in downtown Riverdale where older buildings are located adjacent to the river. Old-timers maintain that flooding never occurred until about 40 years ago when several hundred acres of the wetland were drained and converted to farmland. Newspaper records seem to bear out that flooding was not a problem historically.

The city health officer is concerned about reports that the river water has recently been tested by the State Environmental Pollution Agency and found to contain levels of the herbicide atrazine in excess of those safe for drinking water. Although Riverdale gets its drinking water from an underground aquifer, that aquifer is unusually shallow.

Recently, birdwatchers have reported spotting wildlife in these wetlands that had not been seen for many years, including a family of swamp rabbits, a pair of mink, and the remarkable sighting of a trumpeter swan.

3. Allow 10 or 15 minutes for groups to prepare the comments they will deliver at the meeting. Groups should argue from the point of view of their assigned personae. Appoint a mayor or take that role yourself. After each group has had an opportunity to express its point of view, the mayor opens the floor for questions, responses, and additional comment.

4. The mayor concludes the meeting by taking a straw vote. Although this vote will not be binding, the mayor wants to get a sense of public support for the drainage proposal and for the projected housing development.

5. After the vote has been taken, discuss why people voted the way they did. What kinds of interest and information influenced votes? Did individuals interpret the same information in different ways? How much weight was given to immediate economic concerns? To long-range consequences?

A swamp rabbit, rare in the Midwest, and larger than the cottontail.

Great egret feeding on a small fish in a wetland pool.

EVALUATION Students complete one of the following assignments.

1. You are a reporter for the *Riverdale Chronicle*. Write an objective account of the mayor's meeting. Summarize major points of view and the tentative conclusion that was reached.

2. You are a canoeing enthusiast, a devoted bird watcher, and an avid environmentalist. Write a letter to the editor of the *Riverdale Chronicle* stating the case against the drainage proposal. Bring together as many convincing arguments as you can.

3. You are the president of Riverdale Merchant Bank. Although you grew up on a farm that bordered the river and have many happy memories of days spent exploring the wild areas along the river, you are now in favor of draining the wetlands. Write a letter to the editor of the *Riverside Chronicle* stating the case for drainage. Bring together as many convincing arguments as you can.

4. Your congresswoman has asked for constituent response to proposed legislation that will set aside in perpetuity an extensive wetland in your state. More than 70% of the wetlands in your state have already been drained. Write a letter expressing your endorsement of or opposition to this legislation. Clarify who you are and why you want her to vote for or against this legislation.

Activity Twelve: Wetland Views and Reviews

OBJECTIVE to demonstrate some of what has been learned in the study of wetlands

SKILLS information gathering, aesthetic perception

MATERIALS the set of 20 slides that accompany this wetlands package

COMMENTS This activity is based on the assumption that the slides and their accompanying commentary were used as an introduction to the wetlands activities. If that was not the case, you will not want to use this activity without some other opportunity for students to see the slides and hear or read the commentary.

PROCEDURE 1. Show the slides, this time without commentary. This reshowing is not for purposes of discussion or review but only to remind students of the subject matter of the slides.

2. Divide the class into network news teams of five or six members each. Assign four or five slides to each team or allow teams to make their own choices. The number of slides each team receives will be determined by the number of students in your class and the number of teams. Any remaining slides may be distributed by lottery. Cut slips of paper, one for each team. If, for example, two slides remained unassigned, put an X on two slips. Teams drawing slips with X's receive a bonus slide.

3. Each network news team is responsible for developing a scenario for the evening television news that uses all of the slides it received. Set a time limit for these presentations, but encourage students to incorporate as much information about wetlands as possible. A panel of experts, for example, might be interviewed with appropriate commentary when the slides are shown. An ecologist, a representative from the State Environmental Pollution Agency, and a local produce farmer with land adjacent to a wetlands might debate a wetlands issue, with the newscaster officiating. An investigative team might be in the field reporting back on what they have found out about a wetlands problem (or solution); again, their report will incorporate the slides. A junior high science class may have visited a local wetlands, and the students may be appearing on the evening news as part of a series titled "Science Education for the 21st Century." Students will have no difficulty coming up with creative scenarios if they are given enough time to prepare. Several short work periods over a week are probably more productive than a single longer session.

4. Set aside a time for the presentations and audience response. You might want to prepare a brief checklist that students can use to evaluate each presentation; the evaluation criteria might include amount of information given, accuracy of information, plausible scenario, integration of slides, quality of performance, fairness, and objectivity.

EVALUATION In a sense, this activity serves as an evaluation for the entire wetlands unit and needs no evaluation other than your own assessment of what your students have learned. You might, however, expand the audience response mentioned in the procedure. Each student chooses one of the news stories and writes a letter to the network praising or objecting to the information given and the implicit or explicit attitudes shown. These letters should be shared with the class and discussion of them encouraged.

Appendix A: Slide Commentary

This commentary on the wetland slides that accompany this publication has been placed in an appendix to allow flexibility in the slides' use. The slides may be shown as an eye-catching and informative introduction to midwestern wetlands; they can also be viewed in conjunction with the teacher's mini-lectures based on the material in Part One and whenever appropriate to a given activity in Part Two. Some slide cues are given in the text, and teachers will doubtless find other opportunities for their use. Activity Twelve, Wetland Views and Reviews, uses the slides in a concluding assignment that encourages students to demonstrate what they have learned from their study of midwestern wetlands.

The slides are numbered in rows from 1 to 20, moving across the plastic sleeve. The numbers preceding each comment below correspond to the slide numbers.

1. The first response of an individual who sees (or better yet, walks through) an area such as the one shown here may be "Yuck, what a terrible place!" Yet nothing is further from the truth. Pictured here is a natural prairie pothole, a low area gouged out by a retreating glacier that holds water for all or part of the year. The soil beneath the shallow water is hydric (wet for most of the year and low in oxygen). Note the small yellow flowers of the carnivorous bladderwort emerging from the water. Beneath the surface, the roots of this plant have tiny bladders that catch small aquatic animals upon which it feeds. The emergent plants in the left center are bulrushes. Much of the Midwest once looked like this before settlement by Europeans.

2. Another type of wetland formed by glaciers is the large pothole shown here. An immense chunk of glacial ice broke off from the main body of the glacier and slowly melted to form a low area surrounded by mounds of glacial debris. The large, emergent plants seen here are cattails, perhaps the most common wetland plant. Notice that even though this area is classified as a wetland, no standing water is visible. The soil, however, is saturated with water and stays very moist for all or most of the year.

3. This great egret is fishing in a backwater lake. Its long, feathery plumes are characteristic of the adult during the breeding season. By 1900, this large wading bird had been nearly extirpated from the United States by plume hunters who sold the feathers for use on women's hats. In 1916 the selling of egret plumes was made illegal, and bird populations began to recover. The backwater lake shown here was formed when the Illinois River overflowed and its sediment-laden waters cut crevices through its banks. As the water escaped, the river valley came to resemble a boundless marsh. Subsequently, dams built on the river in the 19th century covered many of the wetlands and formed numerous large backwater lakes.

4. The floating leaves and flowers of the water lily, anchored from below by a thick stem, can dominate the margins of ponds and the quiet backwaters of upper midwestern rivers. Lying directly on the water, the leaves of the water lily have evolved special features (adaptations). The stomates or openings involved in gas exchange are found on the upper leaf surface instead of the lower surface as in most plants. In addition, the upper leaf surface contains wax so that water rolls off easily and avoids clogging the stomates.

5. The surface of the water is green, broken only by a fallen leaf or the bas-relief of a hidden frog. This uniform blanket is composed of hundreds of tiny, free-floating plants called duckweed. Each is a separate organism and may or may not have a single, dangling root. Duckweed is a favorite food of ducks, geese, and muskrats and has a higher nutritional value than most agricultural plants. The camouflage provided by duckweed for small frogs trying to hide from predatory birds can be excellent. How many frogs do you see in this picture?

6. A female mallard with her young float placidly on a shallow expanse of open water. Mallard eggs hatch in synchrony, and as soon as the young are dry, they get wet again as they follow their mother into the water. Broad ponds, deep marshes, and prairie potholes, ringed with dense vegetation and teeming with insects, provide abundant food and protection for this dabbling, or puddle, duck. Mallards obtain their food by tipping up on the water's surface to reach organisms on the bottom with their bills. Nothing is visible from above except their bobbing rumps.

7. Early spring brings the deafening trilling and crooning of male toads to the margins of many wetlands. The male's throat is distended into a conspicuous, light-colored sac larger than its head. This vocal sac is a loose pouch of skin that inflates with air and acts as a resonating chamber to intensify the sound made by the toad's larynx. Amorous toads are so intent on finding a mate that they often make an easy meal for any passing snake or large wading bird.

8. Round and round and round the whirligig beetles dart, in dizzying circles within the surface film of the water. Large groups of these shiny, almond-shaped beetles are seen only in the fall and spring. During the summer months only the larvae are present, and these are found underwater. Whirligig beetles are the only members of the order Coleoptera to swim within the surface film, and they have several adaptations to aid them. Only the upper body surface is water repellent; thus, they swim half above and half below the water. Their compound eyes are split in half so whirligigs can see both above and below the water. In addition, the second and third pair of legs are shorter and flattened, making them ideal for swimming.

9. This adult mayfly is merely resting on a showy lady's slipper orchid before joining the large swarms of its comrades soaring, dancing, and dipping in the air above the marsh. Mayflies are a familiar sight near any body of fresh water. The adults do not feed because they have no mouthparts, and they live only long enough to mate. Their guts are filled with air to improve buoyancy during flight. The adults are important components in wetland food webs because they are eaten by many animals. The immatures (nymphs) live a year or more on the bottoms of lakes and streams, eating large quantities of dead plant and animal material (detritus). The presence or absence of mayfly nymphs is used by scientists to monitor water quality because these insects are sensitive to changes in dissolved oxygen in the water.

10. Distinctive wetland forests develop on the often vast floodplains along larger rivers and streams. These are called bottomland or floodplain forests. No forest type is more important to the rivers and streams that crisscross the Midwest. The trees stabilize the banks, slow erosion, and create migration and habitat corridors for wildlife. Unfortunately, the soil that is annually enriched by silt from the flooding streams and rivers has proved too tempting to agriculturalists, and each year many thousands of acres are converted to cropland.

11. The stillness of a midwestern swamp brings to mind the bayous of Louisiana. Duckweed covers the surface in a thick green blanket. The cypress trees, once existing in vast stands across the lower Midwest, support little colonies of stick-tight sunflowers on their knees. In general, swamps are areas where the soil is saturated or covered with surface water for most of the growing season and dominated by woody vegetation (trees and shrubs). The water level in a swamp may fluctuate by several feet from year to year, but without such changes species like the bald cypress could not reproduce. Its seedlings require dry ground early in their development.

12. Although a bog may appear to be a swamp or marsh because it is perpetually moist, it differs from those wetlands by the high degree of acidity concentrated in its dark, quiet waters. Because of the lack of decomposer organisms, the process of decay is very slow in a bog, and dead, partially decayed vegetation (peat) accumulates in large quantities. Because very little soil is present, plants must grow in the ever-thickening layers of peat. These layers float on the water and form a quaking mat that is difficult to walk on without sinking in or even falling through! Due to the lack of certain nutrients, especially nitrogen, plants have developed various adaptations to survive here. Pitcher plants (foreground) and sundews (red patches) are examples of insect-eating plants that get their nitrogen from digesting captured insects. Certain wild orchids (see slide 9, for example) have developed a symbiotic relationship with acid-loving fungi that live on their roots and provide essential nutrients to the plant. Tamaracks (larch) are coniferous trees that lose their needles during winter; their roots help bind the peat together to form hummocks.

13. By late spring the large green leaves of skunk cabbage begin to unfurl and shade nearby vegetation. The flowering part appeared early in March, melting its way through the snow. This purplish-brown structure, with an odor of rotting meat, attracts flies for pollination. Skunk cabbage occurs in seeps in the northern Midwest and can be used as an indicator plant because it typically outlines the boundaries of this habitat. Remember to wear boots when visiting a lush seep habitat; otherwise the water in the supersaturated soil and muck may "seep" in and fill up your shoes!

14. Swales occur on both the east and west shores of Lake Michigan, the west shore of Lake Huron, and the southern shore of Lake Superior. Superficially, these sites resemble the typical tallgrass prairies that occur along railroad tracks and in pioneer cemeteries in much of the Midwest. Although the soil of the swales seems to be mucky, it is chiefly composed of sand, which is perpetually moist. The swales are dominated by sedges, rushes, and marsh grasses. Wood lilies, black-eyed Susans, and Indian paintbrush intermingle with the sedges and rushes on the moist sand. Swales are a transient (short-lived) community. They gradually fill up with humus (decayed plant and animal material), become better drained, and eventually succeed (change) to forests.

15. The green-backed heron is found along creeks, near the edges of ponds and lakes, and in swamps. This species is a secondary or tertiary consumer (carnivore) that stalks the water's edge in search of fish or crayfish. The green-backed heron usually fishes from shore or from a perch, preferring not to get its feet wet. When food is spotted, the heron crouches low on its legs, draws back its head, and crooks its neck. It seldom immerses its head while fishing. Once caught, prey is held crosswise between the tips of the mandibles (beak), then tossed up and swallowed head first.

16. Arrowhead is usually found in shallow water or saturated soils. Its habitat includes pond, lake, and stream margins as

well as marshes and swamps. Arrowhead is considered an emergent plant because most of its foliage is above water. In addition to the broad, arrowlike leaves that extend above the water, the plant also has long, narrow underwater leaves similar to grass blades; these can withstand water currents and help to reduce turbidity by catching solids in the water. Along the roots are potatolike starchy tubers. Ducks, geese, swans, and muskrats feed upon these, lending another common name for the plant—duck potato.

17 and 18. As streams drain to lower ground, they develop a floodplain. At flood time the water rises into a broad sheetflow that proceeds evenly and slowly through trees, marsh grasses, and other floodplain vegetation. By slowing the velocity of floodwaters, floodplain wetlands act as sediment or siltation traps that accept the load of nutrients and sediment brought by the floodwaters. Thus, a floodplain is a better flood control device than a reservoir because it saves water from evaporation, never fills with sediment or silt, and provides a continuous habitat corridor for wildlife. Note the watermarks on the trees that denote degrees of flooding and the meandering course of the stream through the marsh before it enters a large lake.

19. Wetlands are home to many organisms. Slider turtles prefer swamps, ponds, lakes, and shallow streams that have soft bottoms and dense vegetation. Their large, webbed hind feet make efficient paddles for swimming. Their front feet are not as heavily webbed and are used for tearing apart food and for crawling along the bottom. Much of their time is spent basking in the sun, often on a log, and never very far from water. Basking increases their metabolism, discourages the growth of algae on their shells, and helps control external parasites such as leeches. At the slightest disturbance, however, they quickly "slide" into the water and disappear. Young turtles eat aquatic insects, crustaceans, mollusks, and tadpoles but turn to a diet of plants as they mature.

20. In the past, wetlands were considered insect-ridden, dark, and forbidding wastelands—places to be avoided at all costs. Artists, novelists, and poets, though, were among the few enlightened individuals to appreciate the beauty of wetlands. Consider Thoreau's Walden Pond or Monet's water lilies. Although less than half of the wetlands that existed in North America at the time of European settlement remain, we are beginning, however slowly, to acknowledge their great practical and aesthetic values. Much of their practical value is directly related to fulfilling the basic human need for water, but their other functions—including flood control, the provision of wildlife habitat, pollution filtering, and ecosystem stabilization—are equally important. Wetlands are also beautiful. Ducks rising from a marsh in an early morning mist, a cottonmouth slithering away on a duckweed-covered pond, an otter playfully teaching its young to swim, or a trumpeter swan placidly floating on a marsh covered with pond lily are unforgettable sights. These images are, in the words of the English poet John Keats, "a thing of beauty." Let us hope they remain "a joy forever."

Aquatic nets can be purchased from biological supply houses, but they also can be made at home or in the classroom.

Materials

- large wooden dowel or discarded broom handle 4–6 feet long
- sturdy wire (no. 4 or 6) approximately 50" long, to be bent as shown in Figure 1.
- white muslin cloth for bag (Figure 2) and canvas cloth (or other sturdy cloth) for rim band (Figure 3)
- hose clamps to secure frame to handle
- needle, thread, straight pins (sewing machine is preferable)

Construction

Net bag. Cut two muslin triangles with the dimensions shown in Figure 2. Sew the triangles together along the seamlines, allowing 1/2 inch for the seams. Turn the bag inside out so the seam edges are on the inside. Fold a band from the canvas cloth as shown in Figure 3 and pin it around the top of the net bag (Figure 4). Leave approximately 4 inches of the bag unbanded to allow room to insert the wire frame (Figure 5). The final product is a two-sided bag that slides onto a three-sided wire frame. Because the top of the net will receive most of the stress during sampling, double stitch where the canvas and muslin cloth are joined.

Frame. Shape the triangular frame as shown in Figure 1; make one stem 1/2 inch shorter than the other.

Handle. On opposite sides of the handle, score grooves for the two wire stems. Use a small wood gouge or a sharp knife. Drill two holes that match the diameter of the wire at the end of each groove to accommodate the end of the wire (Figure 5).

Assembly

Thread the wire triangle through the band at the top of the bag. Position the wire frame into the handle using the grooves and holes and fasten securely with one or two hose clamps (Figure 5).

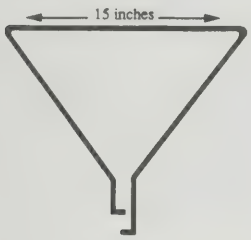


Figure 1

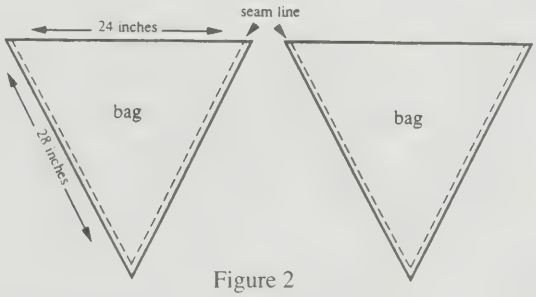


Figure 2

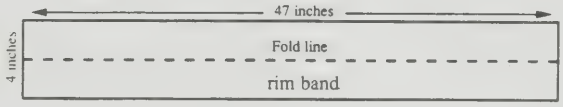


Figure 3

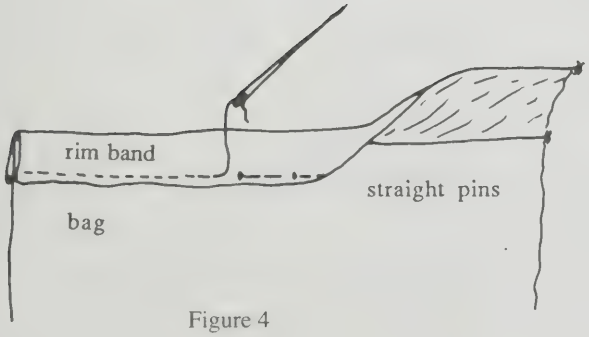


Figure 4

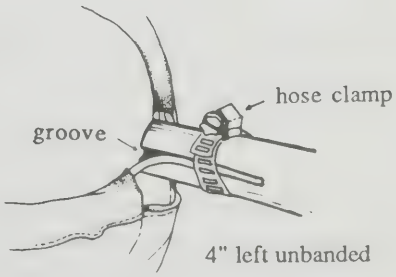


Figure 5

Glossary

abdomen the section of an insect's body that contains mating structures as well as reproductive, digestive, and breathing organs
absorb to take up; for example, plant roots absorb water
acid (acidic, acidity) a substance with a pH less than 7
adaptation modification of an organism to make it better suited for the conditions of its environment
alkaline (alkalinity) (basic) having a pH greater than 7
amphipods an order of small freshwater crustaceans with laterally compressed bodies
anaerobic living or functioning without free oxygen
animalcule a minute microscopic organism
anterior the front or head end of an organism
aquatic growing or living in water
backwater (bottomland) lake a lake formed when a river (stream) is turned back in its course by an obstruction, usually sand or soil, that causes the river to form a side channel completely separate from the main river
bedrock solid rock underlying the soil
biology (biologist, biologically) the science of living organisms and their processes
botany (botanist, botanical, botanically) the scientific study of plants
bryozoans marine and freshwater animals that live in colonies and superficially resemble mosses
carnivore an organism that feeds on animal tissue
carrying capacity of an ecosystem the number of individuals that the resources of an ecosystem can support
cilia (cilium) fine, hairlike outgrowths found on the surface of some cells and capable of whiplike, beating movement
copepods small, free-living or parasitic crustaceans that are related to the shrimp but that have no carapace (shell)
crustacea (crustacean) a class of mainly aquatic gill-breathing arthropods usually having two pairs of antennae and often a hard carapace (shell)
decomposers (decompose, decomposition) organisms that break down dead organisms or plant matter into simpler parts
degrade (degradation) to wear or break down
detritivores organisms that feed on or obtain nutrition from the dead or decaying remains of other organisms
detritus small pieces of dead and decomposing plants and animals
ecological benchmarking information obtained in a uniform way over many years documenting changes in the physical and biological make-up of a habitat (includes seasonal changes)
ecological integrity the condition in which a substantial percentage of the organisms remain in an area relative to the number that occurred there when the area was pristine
ecology (ecologist, ecologically) the relationships among organisms and their environments
ecosystem a relatively self-contained ecological system defined by the types of organisms found in it and their interactions
emergent plants plants rooted in the water but having most of their vegetative growth above the water
entomologist (entomology) a person who studies insects
environment surroundings of an organism, including the plants and animals with which it interacts
erosion the wearing away of landforms by the action of wind, water, or glacial ice
filter (filtration) any porous substance that can separate matter in suspension from a liquid or gas that is passed through it
flagellum (flagella) a long, whiplike or feathery structure borne either singly or in groups, capable of propelling a cell through a liquid medium
floating plants plants on the surface of the water
floodplain level land that may be submerged by floodwaters
food chain a sequence of organisms in which each is the food for the next member of the chain
food pyramid (see **trophic pyramid**)
food web a diagram that shows the feeding relationships among organisms in a community
groundwater water found below the surface of the soil
habitat the locality or the environment in which a plant or animal lives
hemoglobin an iron-containing pigment that carries oxygen in the blood
herbivores organisms that feed entirely on plants
hydric soil soil that is wet most of the year and low in oxygen
hydrology the science of the distribution and circulation of water on the surface of the land, in the soil, and in the atmosphere
hydrophytes plants growing in water or in soil too waterlogged for most plants to survive
inorganic soil soil composed of minerals with no plant and animal matter
inventory (noun) an itemized list or catalog; (verb) to make an itemized record—for example, to estimate the wildlife of a region

invertebrates animals without backbones
metabolism the chemical changes in living cells by which energy is provided for vital processes and activities and new material is assimilated
nutrient any substance required for growth and maintenance of an organism
nymph the larval stage of development in incomplete or gradual metamorphosis
omnivore an animal that eats both plants and animals
organic soils soils made from decayed plants and animals
organism any living plant or animal
oxbow pond a U-shaped pond formed when a meandering river changes course and leaves a portion of its channel isolated except when the river floods
pH the measure of acidity or alkalinity of a solution
photosynthesis the process whereby plants convert sunlight to plant material
phytoplankton minute floating marine or freshwater plants
pollution (pollutants) the contamination of the environment with man-made waste
posterior the rear end or toward the rear end of an organism
precipitation the deposition on the earth of hail, mist, rain, sleet, or snow
predaceous living by preying on other animals
primary consumer an organism that obtains food (energy) from the trophic layer below it, and is in turn food (energy) for the trophic layer above it; a herbivore
primary producer plant, algae, or other photosynthetic organisms that produce the energy of a food chain; the bottom layer of the food pyramid
replication duplication
runoff the drainage of water from waterlogged or impermeable soil
sample (sampling) a representative part of the whole
saturated full of moisture, soaked
secondary consumer a carnivore that eats herbivores; feeds on primary consumers
silt sedimentary material with fine particles of uniform size between sand and clay
sediment (sedimentation) material that settles to the bottom or is held in suspension in a liquid; the particles may vary in size
soil type a category determined by water-holding capacity and parent materials; for example, silt, clay, or sand
species diversity the number of species in a given area
stoma (stomata; also **stomate** and **stomates)** a minute opening between certain epidermal cells of a leaf through which gases, including water vapor, enter and leave
submerged plants plants growing under the water's surface
subsoil the layer of weathered material that lies under the surface soil
surface tension a property of water (and other liquids) created because the water molecules are more strongly attracted to each other than to the air above
surface water water that occurs at or very near the surface of the earth
terrestrial living or growing on land
thorax the middle body section of an insect and the location of the locomotor appendages, including legs and often one or two pairs of wings
top carnivore the top consumer in a food web or trophic pyramid
toxic poisonous
trophic having to do with nutrition as in the feeding relationships in a food web or food pyramid
trophic pyramid a graphic arrangement to illustrate nutrition (trophic) levels with producers (green plants) forming the base, followed by first, second, third, and subsequent levels of consumers (animals); each layer depends upon those supporting it. Such a pyramid usually ends with a "top carnivore."
turbid (turbidity) muddy, cloudy; said of water with sediment in suspension
uplands high land; ground elevated above the lower land along rivers or between hills
vertebrates organisms that have internal skeletons with a backbone or spinal column
water table the upper limit of the portion of ground that is entirely saturated with water
wetland land in which water is the controlling factor in the environment, characterized by hydric soil, a water table that remains at or near the surface, and plants that tolerate life in water or in saturated soil

Learning More about Wetlands

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